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BULLETIN OF THE ATOMIC SCIENTISTS

Founded in 1945 by Hyman H. Goldsmith and Eugene Rabinowitch

Vol. VII August, 1951 Nos. 7–8

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Published monthly by the Educational Foundation for Nuclear Science, Inc., 956 E. 58th Street, Chicago 37. Phone: MIdway 3-3056. Manuscripts should be sent in duplicate to the Managing Editor at the above address. Publication date: 15th of the month. Subscription and advertising service: All correspondence in regard to changes of address, new subscriptions, and advertising rates, should be sent to 53 W. Jackson Blvd., Chicago 4, Ill. Subscription—$5.00 a year. Single copy—50 cents. Four weeks notice is required for change of address: both old and new addresses must be given. Entered as second class matter at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

The opinions expressed in the "Bulletin" do not represent the official views of any organization. Copyright, 1951, by the Educational Foundation for Nuclear Science, Inc., Chicago 37, Illinois.

Editorial

KOREA MUST BE REBUILT— A TASK FOR THE UN

THE fighting in Korea seems all but ended. True, as this is written, the preliminary negotiations at Kaesong have just begun—and have already run into the first snags. If these negotiations succeed in bringing about a formal armistice conference, the latter may break down—for example, over the question of inspection—or it may drag on indefinitely. Even if a military armistice is concluded, a political peace settlement for all Korea, acceptable to both sides, will remain difficult if not impossible.

However, it seems that the Communist leadership has decided that it wants the fighting in Korea to stop; and the anti-Communist leadership decided in favor of this several months ago. When the United Nations' troops succeeded in establishing a cohesive front across the Korean peninsula, solidly resting on both ends on Allied-dominated Seas, their superiority in equipment began to tell, and the Communists' hope of pushing the UN troops off the peninsula has all but faded out. The American command, renouncing the attempt to advance again into the widening funnel of Northern Korea, or, beyond it, into the wide expanses of continental Asia, has dimmed the alternative hope the Communist command probably has entertained—that is, of engaging America in indecisive, exhausting, and frustrating fighting of the type of the French campaign in Indo-China, or the Japanese war in China, without incurring disproportionate losses in its own trained manpower and equipment.

With neither side capable of bringing the Korean War to a decisive end, and therefore reluctant to continue it, it is unlikely that large-scale fighting in Korea will be resumed; and, even if this should happen, it is unlikely that this new flare-up will lead to anything but another stalemate, at some other line across the Korean peninsula—even if it may be farther from the 38th parallel than the present front line. War might end without official peace, or even without official armistice—recent history has accustomed us to wars beginning and ending without the formalities which have been considered indispensable in the past.

Despite the uncertain outcome of the present negotiations, it is therefore proper to ask now: After the fighting in Korea ends at or near the present front line, what next?

II

The only official (and, we believe, also the only real) aim of the United Nations' intervention in Korea has been to protect the Korean Republic from imposition of a Communist dictatorship by force of arms. It was believed—probably justly—that if the attempt to extend the Communist rule over Southern Korea by military action had remained unchallenged, this would have swept away all chances for the United Nations to serve as an effective organ of collective security in the future, destroyed belief in the United States as its *bona fide* supporter, and served as a prelude for aggression elsewhere.

In the heat of war, the fact that this war was fought for the Korean people has often been all but forgotten. American papers gleefully displayed headlines such as "Red Stronghold Levelled," "Red Town Ceases to Exist," or "Red Port Battered 30 Days in Succession"—forgetting that the towns or ports were not "Red" but Korean, and that whether it was in South or in North Korea, the people whose homes and means of livelihood were destroyed and who were killed by the hundreds or thousands—men, women, and children alike—were Koreans; that even those of them who were officially "Reds,"—that means, domiciled in the North Korean Communist state—had become such not by their choice, but by the decision of the great powers—including the United States—who drew an arbitrary straight line across the country six years ago. It may be that the aerial bombardment of any building in which Communist troops could have been hiding, and strafing of every column on the road in which Communist soldiers could have been concealed, was the only possible way to overcome, at certain critical times, the tremendous Communist advantage in manpower. But the use of these indiscriminate methods of warfare, the triumphant reporting of their results by the United States Air Force and Navy, and the gloating of a large part of the American press over them has sent a shudder of fear and aversion through the countries of Asia and Europe, who can easily imagine themselves as future Koreas, and has provided the Communists with material for highly effective anti-American propaganda. Not less repulsive—and also bad politics—was the official statement, loudly taken up by the press, that the purpose of the UN forces in the last period of the war was "to kill Chinese"—with the press printing daily triumphant summaries of the success of this extermination program. That most of the exterminated Chinese "volunteers" were but conscripted recruits of Communist dictatorship—many of them former Nationalist soldiers captured by Communists in the civil war—was not mentioned. The decision to aim the strategy, from the time of the massive Chinese intervention, not at capturing towns, but at destroying the manpower and equipment of the enemy, may have been militarily sound and inevitable; but daily boasting of the slaughtering record of this program was not a good way to convince the peoples of Asia of American humanitarianism and of American sympathy and respect for Asians.

III

Now, it is time to return to the spirit of the first days of the war, when its only aim, to protect the people of the Korean Republic, was clearly stated by American leaders and unanimously supported by all nations not silenced by Communist dictators. Then, the challenge of military aggression was taken up by the United Nations. Now, as the fighting ends, the United Nations, and America as their main protagonist in East Asia, are confronted with a new challenge—to repair, in the shortest possible time, the destruction inflicted upon Korea by the war UN forces have so stubbornly and often ruthlessly waged on her behalf. The American people have read in the newspapers and heard from their own

military leaders about the utter devastation which the ebb and flow of the war has left in Korea. They know of the dead cities, villages that have disappeared from the map, and of the millions of refugees plodding along roads or huddling in crowded camps.

The millions of dead Koreans, innocent victims of a war fought on their behalf, cannot be returned to life; but the millions of dwellings destroyed—largely by American aerial bombardment, or by the artillery fire of American sea and land forces—can be rebuilt, or replaced by new and better ones. Homeless refugees can be resettled, children sent back to schools, and the industry and agriculture of the country brought back to a level equal to or higher than it had been before June 1950.

Unless this challenge is met, the United States and the United Nations will have shown to the nations of Asia and Europe that while they are ready to spend billions of dollars and thousands of lives to resist the destruction of these nations in the Communist empire, they are indifferent to the devastation and ruin which this resistance brings upon those whose freedom it is meant to protect.

The situation calls for more than a piece-by-piece reconstruction and gradual economic rehabilitation—one more of the many assistance programs carried out under the auspices of the United States or of the United Nations in various parts of the world. The decision to rebuild Korea must be as solemn as the decision to defend it with arms was a year ago, and its implementation equally urgent. The investment of money, material, and effort into this reconstruction program must be as unstinting as has been the appropriation of means for the military action.

Let the General Assembly of the United Nations, in a meeting as historic as the one in which they accepted the challenge of aggression, solemnly declare it their responsibility to rebuild the country which has suffered under this aggression and its repulsion by the force of arms. The United States should take the initiative in proposing such a resolution to the General Assembly and accept the same responsibility for carrying the reconstruction through as she has accepted the responsibility for assembling and leading the forces to meet the aggression. Let the General Assembly appeal to all its members to contribute to this task as it has called for troop contributions in the past. Many nations who have been unable or reluctant to provide armed contingents may be able and willing to contribute important materials and skills to the reconstruction.

IV

Several authors, writing on the problems of underdeveloped areas, in this and earlier issues of the *Bulletin*, have sounded warnings against an easy belief in the possibility of rapid, spectacular improvements of the economic status of the underdeveloped nations of Asia. Demographic experts have pointed out that rapid population increase—an inevitable consequence of improved sanitary conditions in an agrarian society—is likely to wipe out whatever increase in production can be achieved in the near future. Those who have studied the problems of increased production have warned that shortage of trained personnel and of energy resources precludes rapid industrialization of these countries and permits only a gradual and limited progress.

These warnings do not apply to the reconstruction of Korea. Here, the task is to put back on its feet an economy that has already existed; to restore the standard of living of a nation that has not expanded in numbers, but has lost, within a year, a substantial proportion of its population.

V

Here is a task to which scientists and technologists of all countries should and would gladly lend their knowledge and skills. Even those who have been reluctant to participate in research and development for military purposes will gladly join in it. If money and materials would be made available even half as freely as they have been (and will be again) provided for military armaments, it should be possible to achieve the restoration of the cities, villages, and industries of Korea, and the resettlement of the millions of displaced Koreans in a few years. The consequent strengthening of the United Nations' prestige and of the American moral position in the world would alone be worth this expenditure.

Korea has become the symbol of the readiness of America and the United Nations to protect the freedom of nations. It must become the example of what collective assistance can do to achieve reconstruction after the devastation of a war fought for this freedom.

Leading experts in agriculture, housing, sanitation, and other relevant fields of science and technology should be brought together to work out a rehabilitation plan on a scale worthy of the world community of nations. Obsolete forms of agrarian economy should not be permitted to stand in the way of agricultural progress and prevent the creation of a satisfied and loyal peasantry—as this has happened in the past in many countries of the Far East, including Korea. The government of the Republic of Korea owes to the thousands of Americans and other allies, whose sacrifice has prevented the slaughter of landlords and independent farmers in South Korea and the collectivization of their lands, a wholehearted cooperation in the long-delayed agrarian reform, abolition of absentee landownership, and distribution of land to those who work it. The United Nations, by their defense of the Korean Republic, have won the right to insist that the agricultural progress and the political stability of the Republic not be periled by the perpetuation of a landless tenant class, open to Communist propaganda, and willing to take part in uprisings such as have marred the first six years of Korean independence. The Republican Government, however strongly it may be influenced by the landlord class, should have no doubts now that the time for procrastination in the long-promised agrarian reform is past.[1]

As in the armed intervention against Communist aggression, it is important that the peaceful intervention on behalf of economic reconstruction and political stabilization of South Korea be carried out under the sponsorship of the United Nations, and not by the unilateral action of the United States.

The recent reorganization of the United Nations should make it possible to initiate and carry out this program through its General Assembly and the Specialized Agencies. The Communists will have difficulty in presenting this program to their peoples as American imperialist expansion. They may try this, as they did with the Marshall Plan, but the propaganda of deeds speaks louder than the propaganda of words.

—E. R.

[1] The difficulties that the National Land Commission (established by the United States Army Military Government) has encountered in its attempts to obtain cooperation of the South Korean Government in a land distribution program have been described from first-hand experience by Clyde Mitchell, in the *Bulletin*, December 1950.

IMPURE SCIENCE

PHILIP WYLIE

In characteristically pungent style, Philip Wylie upholds the surprising theory that scientists should have protested more loudly or resorted to open rebellion to restore complete freedom of science after the war. Mr. Wylie will be known to most of our readers, if not for his deep-sea fishing stories, for his socio-philosophical writings, such as "Generation of Vipers" and his latest novel, "Opus 21." He has spent years studying physics, and in his latest novel characters were constantly quoting from the "Bulletin of the Atomic Scientists."

IT IS said that "pure science," the quest of "knowledge for its own sake," embodies the loftiest of human motives. Indeed, this idea is so well imbedded in the minds of investigators that I have known several who imagined it to be not just the dominant motive of their lives but the only important motive.

In them, "pure science" corresponded to what other men call "God." It was their Grail and their *raison d'être*, their be-all and end-all, so they thought. And like all other devotees they allowed nothing of which they became aware to interfere with their selfless self-dedication. Pragmatism governed their work; logic, they said, ordered their minds. They ruled out emotion—unless the very asceticism which rejects feeling and sentiment is, itself, an occult emotion.

To be sure, none of these gentlemen was a perfect monk of the laboratory. They came outdoors. They associated with people and even people who were not scientists. They usually did not belong to churches but some belonged to political parties. Others, finding no party to match their theories of government, joined nothing but willingly expounded their own social conclusions. These gentlemen were often married and often had children. In domestic relations, they were not markedly more successful than other men. And in learned areas outside their own they often exhibited credulity, ignorance, prejudice, *à priori* conclusions, and other phenomena characteristic of the rest of us—the biased vulgarians.

Their scientific "purity" as people often was heart- and brain-deep in their elected province of research. Elsewhere, it was sometimes skin-deep, sleazy, or non-existent. But as I have pointed out before, in their work these same gentlemen would not employ any tool—any gauge, say—which they had not tested in every way and found reliable. They would not use a gauge they did not quite know how to operate or a gauge that often stuck or a gauge with calibrations upon which they were not agreed. Nevertheless, they constantly employed as their master tool, themselves—organisms very few of them bothered to check against an increasing body of scientific knowledge concerning humanity.

"THE GREAT MYTH"

Common man invents the myths, as a rule. But one common myth which the pure scientists readily took for their own, lived by, promulgated, and gave official sanction to, was the myth —the inexcusable myth—that science has found out so much it is impossible for any individual to keep up with the Known.

That is perhaps the Great Myth of the twentieth century. It appears true on its face. No man can possibly master the detail of every branch of inquiry and give it back perfectly on demand, like an encyclopedia. But any intelligent man who is not misled by the myth can quite readily assimilate the basic concepts of all the sciences, the principal lines of investigation they are following, and the major new developments as they occur. He can "ground" himself by reading one or two hundred books (not necessarily the "Great Books") and he can keep effectively abreast by following a dozen journals and magazines. Many persons do just that—including even a few scientists.

Thus, what a man can learn concerning his physical environment and concerning those responses to it which he calls his "psychology" may embrace the main, current notions about all that is "known," from the composition of atoms to the nature of the cosmos and from the laws of genetics to those of the unconscious mind, including even his own unconsciousness. He can *understand* these many hypotheses, that is to say—and something of evolution, anthropology, archeology, and a score more sciences, to boot. In every important field, numerous able men have set *the* major findings into language a bright high school graduate can easily follow.

Yet The Myth is universal. Its many corollaries are taken for granted by the learned doctors as much as by the veriest oafs. A principal corollary is this: not since the era of Shakespeare (Spencer, perhaps, Newton or Bacon) has it been possible for the individual brain to grasp contemporary knowledge. If a man follows what has been found out in, say, Medicine, he will have no room in the furrows of his brain even to glance at what the Nuclear Physicists have learned. If he is gifted enough to contain the basic elements of Medicine and Nucleonics, there will surely be no drop of grey matter left to soak up any data on Semantics, or, perhaps, the new Psycho-philosophy of Symbols.

SPECIALIZATION AS OPPOSED TO "AWARENESS"

That corollary is rubbish. For, obviously, every intelligent modern man

can and does soak up far more than was contained in Shakespeare's "universal awareness" and likely, in addition, he specializes in something that conducts him, in one area, at least, far beyond the Bard—three centuries and more beyond. Why, then, does a preposterous fable underlie (and delimit) all—or nearly all—our private pretensions to knowledge?

It is convenient. It perfectly serves the philosophy that has reigned over pure science for more than a century, the philosophy of specialization. The myth makes it apparently possible for the investigator to proceed farther along a single line than he would if he had been obliged to attain something of a general education before specializing. I say "apparently" owing to the fact that much evidence could be put forward to show how knowledge in all areas aids inquiry in any one and to the further fact that special lines of inquiry converge and merge, these days, so that it is difficult to sort out one "science" from another. Genetics, to illustrate, is part of Biology, but when Shrödinger writes about it, Genetics suddenly becomes a branch of Nuclear Physics.

It will be argued, of course, that the very object of "pure" science is to rule out what I have called "man" and that the aim of "knowledge for its own sake" is the attainment of information without regard to human beliefs, passions, and will. True—and noble, besides. Yet if that is all of truth, it follows that certain other "ideals" we hold dear are most unrealistic. Democracy is one. Scientists never tire of advertising the "democracy" of their occupation. Yet democracy rests upon the political theory that a majority of any group, when adequately informed, will make appropriate decisions.

DEMOCRACY AN ILLUSION

It will be seen at once that, so long as the Great Myth is believed, real "democracy" remains an illusion. For, to the extent that scientific findings influence society, the voters, believed incapable of universal insight, will not be adequately informed. They will not be one per cent adequately informed. They will even assume they cannot be and many important scientists will assure them that is the case. Moreover, scientists themselves will be little better off. For, wherever a social problem falls outside their particular domain, they will (as unchecked gauges and because of The Myth) share ignorance with the laymen.

That, of course, is the actual state of affairs today. Mr. Truman, who did not go to college, is trying earnestly to calculate risks of war that involve shocking guesses even for nuclear experts. He is assisted by Mr. Dean, who is not a physicist, by Mr. Acheson, who is probably unable to think of a future war as a bacteriologist might, and by General Marshall, whose background in the studies of fungi is probably nil. It was that sort of "democratic" difficulty which led some of the scientists I have known to subscribe to naziism and others to communism and which fills a great many more with a sense of pessimism-cum-dilemma. A people who, for generations, have been taught that they cannot know, but who nevertheless must act, do so then in avowed ignorance which, usually, they call Faith.

The assumption that the public could be turned overnight, or in years, or in a generation, even, into technological sciolists, is, on the other hand, foolish. A vast body of the public, a large majority, will long remain uneducable in science owing to its cerebral incompetence, its more superficial motivations, or its religious doctrines.

Yet there existed, until recently, here and abroad, among many national majorities, not only an assent to scientific research (even where support was absent) but also an emotional climate or a "philosophy" which fostered inquiry. The general term given to that climate, that philosophy, was "freedom." Insofar as science was concerned, such freedom has long been taken for granted. Under it, science advanced, advancing the people with it.

FREEDOM TAKEN FOR GRANTED

What modern men of science took too much for granted was a brand of that same "freedom" accorded constitutionally to Americans: freedom to investigate as they pleased so long as they did not harm other people; freedom of their scientific press whereby their findings and theories could be communicated; freedom of assembly, wherein they could report and discuss their work. Western man for a long time maintained that franchise for scientists. The masses did not become "science-minded" and did not believe it possible; but they firmly believed (or seemed to believe) that scientists should be allowed to go ahead—freely and openly. That much "democracy" we *had* achieved!

The Nazi dictatorship, with its quasi-heathen "religiousness," blurred such liberty somewhat, but only locally. Geneticists, at least, are nowadays aware that the Communist dictatorship has not only muffled freedom but altered fact to suit its politics. And American physicists, these days, are anxiously metering the air to find out what Soviet experts are up to—more evidence of the world-wide loss of a free climate.

It does not lie within the province of this brief essay to inquire into the meaning of such events from a technical, psychological standpoint. Psychologists and psychiatrists pointed out the signs, portents, and warnings long ago. They saw, in fascism and communism, a regression of Western man from scientific truth and from the climate of freedom toward medieval patterns; they explained it. Any physicist interested in the literature can find it without difficulty though he may deplore it, since most psychologists are not very pure scientists, being doctors, not biologists, and doctors, besides, who are inquiring into a new, uncertain area of truth.

What the "pure" scientists needed to appreciate, and did not, was that the climate of liberty which they took for granted was not necessarily self-sustaining. Few, however, had a concept of themselves as tools in need of as much checking and adjustment as the rest of their apparatus. Fewer still, as a result, appreciated that a function of the pure scientist involved the maintenance and extension of the general function. Humanity could not be rendered logical in all ways and rapidly; but large groups had already become attached to the idea of freedom. So long as this was kept before them as an essential condition of advancement, the people might feel they had "the right" to debate scientific discovery on grounds of dogma or tradition or whatever, but they would also feel obliged to permit a similar liberty to the investigators.

TO OUR READERS

There was no July issue of the *Bulletin*. The editors have incorporated all the July material into this double issue for August.

The "purer" the work of an individual, the larger was his obligation to freedom for he used it more. His brain was his final tool. Its only effective medium was liberty.

Without liberty, the direction of his work could be impeded, his conclusions could be repudiated, and his very hypotheses could be stifled. At the core of learning, the center, the heart, the apex, there might be no "free press" without liberty and no right of "free assembly." To keep "pursuing knowledge for its own sake" where such rights no longer existed would be to perform an act of solipsism, an act of ego and vanity amounting to pathological behavior. For, in the ultimate sense, to pursue "knowledge for its own sake" is absurd; if man's sake is left out, the pursuit must logically be abandoned: the knowledge already exists in the universe; why should any man uncover it save for some human reason?

FREEDOM—A HUMAN RESPONSIBILITY

From that "human reason" for science devolves the human responsibility of scientists for freedom. Freedom, fundamentally, is the room for learning. It is the space, the dimension, in which the mind may discover and grow. It has but a single absolute: freedom of knowledge. This, the scientists have regarded as their very own. They have done it much service by trying to tell all people what they know and by urging any who will to join their ranks. But when, in America, the crisis came, very few scientists indeed saw fit *as men* to defend that needful absolute with valor and resolve. There were few martyrs after Hiroshima. Instead, there were people who refused to work for the government, or for Leslie Groves, or upon weapons. There were people who viewed with alarm the closing of a federal curtain over a portion of physical theory. There were polite, worried lectures. But the scientists of America did not stand as one to cry out, "This shall not come to pass!"

Science on Itself

"It is nonetheless true that science has been astonishingly slow in using the scientific method on itself. Almost every other phenomenon in the world has been surveyed in the cold light of ascertainable facts and dimensions, while the relation of science to other fields of knowledge and activity has had only casual attention."

—*From an Editorial in the* Washington Post

RESTRICTION OF FREEDOM BY ADVENT OF BOMB

The medium, the environment, the public philosophy which their brave predecessors had so agonizingly brought into being was overnight contracted and compromised. Hardly one scientist in fifty looked up from his Bunsen burner to note what had happened. For the first time in America freedom of knowledge was, in part, officially dead. There was a seal over "X" amount of truth. From thenceforward, all but the sanctioned few would be unable to learn even the general nature of what they were not allowed to know.

A surge toward enlightenment that began with Aristotle, with Jesus, even with the old Asian philosophers, once more was stopped and no man could say how far the curtain would fall before the principle was restored. But the scientists—even the pure scientists—did not deem themselves responsible. They neglected their tradition and their heritage. The culture medium, the liberty, in which they had grown was polluted without much protest.

They had, it proved, merely exploited liberty for they would not express it or exemplify it. In that fashion, they were not good gauges—not pure men, wherefore not pure scientists. And that is why, today, so many of them talk vaguely of their collective "sin."

MOURNING OF LIBERTY BY LAYMEN

That all other liberties had their roots in their own fundamental freedom of knowledge was *not* apparent to them. They were swayed by lesser traditions, or owned by businesses or universities or governments—or they had replaced their one valid idea with "social consciences"—or they were "believers" in this or that. When liberty was thus slain at the source her mourners were mostly laymen, like myself.

It was a curious period, the weeks and the months following Hiroshima and Nagasaki. The "atomic scientists," pitched suddenly into the brightest of all limelights, asked and even pleaded for an "open" world.

But those whom I knew were far more alarmed by an immediate prospect. During the war they had worked under the army and they were determined, with the coming of peace, to throw off the military yoke. They merely insisted that science, if it had to be regulated or in part kept secret, must be under civilian, not military authority. To that end they bent nearly all their effort, urging men like myself, who understood something of physics and who "could write" and who had "large audiences," to campaign for the McMahon Bill and against the May-Johnson Bill. When the former passed, they sighed with near-complete relief: civilians, not soldiers, would possess the atom.

I argued then as I do now: scientists cannot accept *any* such authority and still call themselves by their old name. I argued then that civilian authority in a secret world would not assure peaceful development of atomic energy (as so many scientists anticipated) but would, as much as military authority, find it necessary to arm against a secret, arming adversary. I argued that, with the principle of freedom submerged, the area of existing liberties would steadily shrink. That a growing, secret knowledge of the atom would slowly spread a nameless terror among a people unfamiliar with secret government, was the inevitable concomitant.

I protested that trust in secrecy was childish, not only on the acknowledged basis that American "secrets" could be re-discovered, but on the basis that espionage at high levels was a certainty. I protested that the curtain of silence across a portion of physics unjustly cut off all philosophical men from their rightful sources of material for speculation. I predicted that, in a closed world, an arms race would ensue which would destroy genuine liberty, and undermine tranquillity by intensifying terror down the years—with all the horrible social results of terror; and I asserted that, when fear and tension and dictatoring reached some sure but unmeasurable degree, Armageddon would come automatically.

Those arguments and predictions are on my writing record or I would not repeat them here. Many of them I printed against the "better judgment" and even the impassioned urging of my friends, the scientists.

THE RISK OF WAR

The conclusions to which those arguments and expectations led, were these: we Americans, standing loyally

for our one absolute of freedom of knowledge, were obliged to insist (if necessary) on a free and open world even at the risk of immediate war with Russia. It was not a great risk in 1945 for Russia was decimated and our arms were omnipotent. It was their duty, the essence of their purity, that the atomic scientists should make the issue clear—refusing as one to accept the narrow liberty even of civil dictation where the far broader base of everybody's freedom was at stake. Nothing short of the threat of force would ever compel Russia to assent to world freedom, for the Kremlin could not persist as it was constituted if "inspectors" from the wide, free world were allowed to see what the Kremlin had done and was doing to two hundred million human beings.

Those conclusions meant that I believed we should fight at once rather than abandon one jot of American freedom of knowledge. Fight in 1945. In 1946. Or now. I then believed that scientists, led by the nuclear physicists, should dramatize the issue—if necessary, by striking—not against the government per se but against *any* policy of secrecy. It seemed their duty.

The issue was a clear one between the continuum of freedom, of pure science and pure scientists, and a retreat into the self-enslavements of a new medievalism and a new kind of political dictatorship. So simple was my mind that I believed the risk of war a lesser folly than the loss of freedom. I still do. An American public, faced with the flat refusal of scientists to accept secrecy would have been obliged to take charge of Russia, by force if need be. The world, including the people of USA, would have learned a mighty lesson in freedom. And Doomsday would not be around the corner now.

QUASI-DICTATORSHIP—THE RESULT OF LOSS OF PRINCIPLE

But the scientists, like the politicians, appeared to think we could safely abrogate our most basic right until we had settled the issue in the United Nations with a Baruch Plan, or something. Both evaded principle; both seized what seemed to them an opportunity for less costly politicking. And nothing whatever was accomplished. In the end, Russia was allowed to commit a gigantic act of aggression against us—an act that cost us our one binding ideal.

Today, the United States of America is a quasi-dictatorship operated chiefly by civilians for military ends. Neither the voter nor his representatives in Congress have any adequate insight into the basis of policy. Neither has enough information to appraise in any useful fashion the perils of our quondam Republic. We do not know what weapons we have or what ones our potential enemy may have. Billions are spent without our comprehension.

We are being prepared—we are not told how—for a war the nature of which we guess and dread but do not really know, a war that grows more terrible every time a scientist has a new hunch here or in Russia—by men who hold this formidable power over us but who have no background for understanding or for extrapolating on the sciences they intend to apply and to oppose. It is no wonder that millions of Americans look toward the future with apathy, or despair, or simply refuse to look. Much that "citizenship" and "government" used to mean has already disappeared; in its place has come a progressive horror as real as lightning but nearly as secret as the other side of the moon. Psychologically, we laymen of the world are reduced to the situation of barbarians again; it will not be astonishing if, come Gabriel's Atomic Trump, we behave barbarically.

In that situation, I think, lies a fact that at least partly explains how the chain of disaster commenced. To the atomic physicists and their associates in engineering, after Hiroshima, "secrecy" did not seem a great menace. They had worked under it for years and had come to feel it was chiefly "military" secrecy which was odious. They expected, furthermore, that under civil authority, they would be "cleared" to know what few secrets of atomic ordnance would be preserved. Their own access to knowledge thus would not be diminished — they thought.

So they felt no sense of personal disaster, of private loss, in the prospect of putting underground a little of their applied knowledge or even some "pure" segments of it. Like other men in short-sightedness, they did not adequately dread what they thought would not harm them in person.

They were a little awed at themselves, too. They had contrived something so colossal that they felt they needed help—the help of everybody—in deciding what to do about it in the future. They seemed to feel their own principles, however lofty, should be subjected to public review and possible revision. They asked for guidance, in short, where they should have been best equipped to guide.

That, I believe, is the case against the purity of our scientists.

"Irresponsible Freedom"

"Investigation of nuclear problems is farther from being foolproof than anything the world has known before . . . if we stand intransigently for the dream of an absolute and irresponsible freedom of the individual scientific worker, we may see some catastrophe which will be followed by a stern Draconian control, in which we have little part."

—Henry Norris Russell

LOSS OF FREE SOCIETY

We still go through the motions of "free men." We continue to talk about the "free peoples" of the world. Meanwhile, in secrecy and all alarming sorts of semi-secrecy, those who actually make our decisions are busy building atomic engines of massive destructive capacity—and busy urging the inhabitants of our cities to prepare themselves to be struck (harder and in more places with passing time) by the same sorts of missiles. It is entirely possible, as certain learned Japanese have suggested, that the nervous system of *genus homo*, whatever his preparations and "civil defenses," simply will not support atomic bombardment.

It is evident, in such case, that any "next war" will be supremely a "war of nerves" in which not necessarily the most sensitive but likely the least sensitive peoples will endure longest and emerge victors by default. And it is obvious, to any physicist worth his salt, that man is not at the end of his weaponeering capabilities but, rather, at a fresh beginning. The "arsenals" of democracy (or of the Soviet) by 1960 will probably contain engines potent enough to wipe out life in areas as big as, say, New Jersey—with better ones in prospect.[1] That is the sort of predicament we face because we

(*Continued on next page*)

[1] For a survey of the known possibilities of the superbomb see article entitled "The Hydrogen-Cobalt Bomb," by James Arnold in October 1950 *Bulletin*.

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(*Continued from preceding page*)

did not stand, when we could have stood and should have stood for liberty: for a simple freedom of knowledge, lawed on the world by ourselves if need be, in order to preserve it at home.

It is quite a predicament.

As a citizen, a layman, and what is called a "lover" of freedom, I watch with unusual interest to see if my friends, the impure scientists, will even get me out alive, let alone get back the liberty I and they have lost.

History some day will notice, I suspect, how near the Americans came to a general realization that all liberties are conditioned by knowledge, and hence freedom of knowledge is the perpetual key to the rest—the absolute, the Great Ideal, to be extended among all men and defended on every perimeter. History will note, also, how we failed there in our current crisis and how the weakness of our adversary—a lack of that very concept—became at least somewhat our own weakness. Whether we shall gain a new vision of the principle in the ferocious years ahead, no man can say. Layman and scientist alike can but hope. But if we do, millenium will be at hand.

The problem of "loyalty" becomes rather trivial in such a frame of reference. Certainly, if my criteria are regarded as in any degree sound, not Russia nor any land but this, offers a good hope of liberty restored. So, I feel, the scientist who understands whence science came and of what ideas he is composed need hardly cavil at the signing of infantile oaths. He has always been asked to sign a similar one upon going abroad, in order to get a passport. Should he object at home?

Should he object even as a special person, one singled out—when he has bent his days to be just that special? Should he demur because the pressure to sign is exerted by men who patently do not comprehend freedom? If so, how can he arrange his logic, since he, the scientist, more than any other kind of man, is responsible for the loss of liberty that has given power to bigots? Let him sign!

Let him sign for a shrewder and more humorous reason than he has caught sight of in all this petty squabble over "rights." Suppose the angered scholars and savants in California had, instead of resisting to the point of excommunication, signed up to the last professor? They could have said, "Now, gentlemen of the Regents, we signed 100 per cent so where are the Commies?" For all the Communists would have rushed to fix their names, and a completed list would then have thrown the problem of "guilt" back into the laps of the stupid pesterers of the people who saw liberty so narrowly, so personally, so theologically—in its sense of befuddled argument.

THE ONE REMAINING LOYALTY

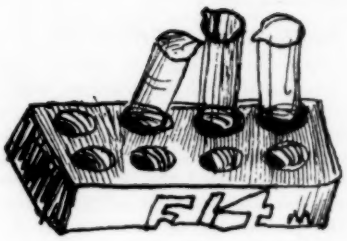
The only possible deep loyalty left for a man of science, if my observations are even somewhat correct, is loyalty to that arming horde which may restore freedom in a pure form. Loyalty is certainly not due a nation that eschewed the concept of freedom and even the very method of science at its ideological beginnings.

Is it not, then, paltering to refuse to swear what one ought easily to be convinced of and to believe in? I would grant a man of science or any man the right to refuse in a truly free country—even the duty. But the current haggle over loyalty merely shows that some of our investigators and students have not yet realized the sort of world in which they now live. It is—all of it—an army and our "side" will remain an army, let us hope, until a victory is won for ideals lately and all too easily relinquished. In an army, one signs what one is told to sign. And the superior officers of what remains of civilization are not men who understand the management of intellect but men who know how to manipulate emotions. With dread dominant, that is quite easy and inevitable, also.

It is too late and too soon to repent of impurity and sin. It is a time to fight. Our abandonment of freedom has left us with no better means than cunning and its final resort: force. But when and if another chance is offered, let the scientists remember the true name of their error: ignorance. For the knowledge they severally have found has made naivete synonymous with death. Complete, not partial or specialized sophistication is the only way that remains to man for the achievement of his dreams. Fortunately, it is the good way, the scientific way. There is no place for children among the wise; but the wise will study child-mindedness with intent compassion, to lead a world of child-adults away from self-harm and, let us hope, to avoid further contamination in the future.

THE ETHICAL PROBLEMS OF SCIENTISTS

KATHLEEN LONSDALE



One of Britain's most distinguished scientists, Dr. Kathleen Lonsdale, crystallographer, has long had a special interest in the ethical problems of scientists. Also keenly interested in world peace, she here presents her own approach to the moral position of scientists during the current armaments race.

MANY scientists are having to think pretty deeply today about the implications of their work and about its ethical significance. They are, of course, frequently blamed for their part in the construction of atomic weapons, and certainly some of them are not quite sure that their consciences are entirely clear. It is a bit disconcerting occasionally to meet a youngster with a few ideals left who is quite sure that whatever branch of science he studies, it is not going to be nuclear physics. Scientists, moreover, are finding that they have influence outside their own subjects, and that they are listened to, particularly, perhaps, when they talk about ethics. As Sagittarius put it: "When physicists talk morals out of turn, It must the Church most seriously concern,"—it is advisable, therefore, for scientists to see that they talk good morals.

When a scientist talks outside his own subject, however, it is particularly necessary that he should define his terms. Martin Johnson pointed out at the British Association meeting in 1950 that a poet, a philosopher, and a scientist, or even different kinds of scientists, may give quite different meanings to such a concept as Time, and that while, until recently, it was common among philosophers to prove that Time must be unreal, today's Logical Positivists would say that the proof and even the problem is meaningless. On the other hand, Martin Johnson said:

" 'Meaningless' is a term which must be carefully used, since, for example, aesthetic and ethical judgments are also unprovable by direct reference to sense-experience or to analytic judgment, but we are all aware that they contain significance which is going to make or end civilized life."

It is well to begin by getting clear in our minds what we mean by science, and what we mean by ethics, and how both differ from religion.

MEANING OF SCIENCE

Science I shall take to mean the study of the world as it *is*, ethics the study of what *ought to be*. In science we include the observation of natural phenomena and of planned experiments, together with mathematical or deductive reasoning based on the results of these and previous observations which lead to theories or statements of supposed laws on which fresh experiments can be based. There is, sometimes, at least in the case of really great scientists, a curious gap between observation and reasoning which is bridged by what John Tyndall called "The Scientific Use of the Imagination."

Now this process of rational observation involves certain underlying assumptions, without which it would hardly be worth while pursuing scientific inquiry. One is, of course, that we exist, and are not merely "a thing in the Red King's dream." Another assumption is that Nature has an orderliness of its own and that deductions can be legitimately made from observation. Some deductions are, doubtless, more legitimate than others; as in the case of the children who were asked what they would think if they went into a room and found cobwebs in all the corners. Most children said that they would think that the person who cleaned the house was careless or lazy, but one little girl said that she would think that a spider had been there. Our deductions do sometimes outrun our evidence, but the little girl would have been right even if she herself had never seen a spider. The acceptance of observations made by other people has a valid place in scientific inquiry, particularly when those observations have been made and confirmed by those whom we can trust to be both honest and accurate. But there is another sense in which our whole expression of physical laws is based on axioms which, so far as we are concerned, may be quite unprovable, although this is seldom realized by physicists unless they are concerned either with atomic or cosmic problems. Milne has pointed out, for example, that the usual assumptions that "time measure" is the same all over the universe and has been the same throughout the history of the universe is not proved. He has shown that there are at least two ways of constructing time-scales, and that the nebular red shifts, if interpreted on the basis of one time-scale, must mean that the universe is expanding; whereas on the basis of the other (variable) time-scale, the same evidence would prove that the universe is stationary. Now either of these assumptions, as Martin Johnson has pointed out, lead us to very difficult conceptions as to what was the state of things "at the beginning." It is as impossible to visualize the idea of a "beginning of time" as of a "beginning of space." An alternative suggestion, recently popularized by Hoyle, is that there is a "continuous creation of matter," and therefore, presumably, a "beginning of matter." Whether we assume this to be so or not, we are apparently compelled to make *some* assumptions, if we are to attempt any coherent explanation of observed phenomena, and

This article is based on lectures given to the Cambridge Physics Society and to the Oxford University Club, both of which were followed by long and useful discussions.

our explanations may well differ with our assumptions.

ETHICS—WHAT OUGHT TO BE

Now any system of ethics must equally start with assumptions, which from the point of view of formal logic may be essentially unprovable, but are nevertheless essential if we wish to consider what the world and we ourselves ought to be or to become. The problem is, of course, with the "ought." How can we decide between one axiom and another? It may be suggested that a wise scientist, faced by equally possible assumptions leading to equally probable, but different, explanations of his observations, suspends judgment until he has more facts. But in ethics we cannot suspend judgment. To refuse to make a choice is, in fact, to make it.

If we stand on a station platform long enough saying "I cannot make up my mind whether or not to take this train," then the train will leave, and the effect will be exactly the same as if we had decided not to take it. Our assumptions in ethics *condition our behavior*, and if we halt between two opinions too long, the effect—which is what really matters in the long run—is that we behave as if nothing could or should be done.

Nor do we have the same criteria for judgment in ethics as in physics. We know that a law of nature cannot be violated without its validity being destroyed. If we have deduced what we believe to be a valid law, and then find that it is not always obeyed, we reject or modify our statement of it without hesitation. We say that "the exception proves (tests) the rule." But we know that laws of morality (say the laws of justice, mercy, or love) can be violated without their validity being affected. They are obviously not always obeyed and will not be obeyed until the whole world has become what it ought to be. If we attempt to test a law of morality by an experiment we do not necessarily get an answer in our own lifetime; or we may not understand the answer we get.

And yet the urge to formulate a system of ethics for ourselves is almost irresistible. We don't merely want to study the universe, we want to make sense of it. We feel, no doubt rightly, that unless we can make sense of it, then there is no sense in studying it.

THE PLACE OF RELIGION

But it is not enough to have a system of ethics: to know what ought to be. There must be a force which drives us to attempt the achievement of our theoretical ideal; and this is something quite different from the ethics themselves. If we do not experience this force, then a discussion such as this remains purely academic; just as academic as to discuss hypothetical crystal structures without making any attempt to discover whether they are in accordance with observations; just as academic as to discuss how to cure a virulent disease without ever attempting to apply our knowledge. And if science deals with the study of facts as they are, and ethics with the problem of what they ought to be, surely it is religion, in the widest sense of that word, that takes us out of the realm of philosophical discussion and into that of action. What system of ethics we adopt, what religion we practice, depends on our fundamental axioms. The fact that these axioms are unprovable by pure reason does not mean that they are unimportant—on the contrary. Vannevar Bush, in *Modern Arms and Free Men*, says "The philosophy that men live by determines the form in which their Governments will be molded. . . . Upon it depends the outcome as to whether life is worth living." Sir Walter Moberly, in *The Crisis in the University*, put it even more precisely and emphatically:

"If the atheist is right, the whole world of religion is phantasy. If the theist is right, the whole world of the atheist is phantasy, for nothing is simply what the atheist thinks it is. Between these two world-views it is necessary to choose. It can plausibly be argued that the religious view is false, but it cannot be plausibly argued that, if true, it is less than all-important."

THE CHRISTIAN ETHIC

Briefly, it seems to me that the choice today must be made essentially between the Machiavellian, the Marxist, and the Christian axioms.[1] These are not altogether mutually exclusive, but since I intend to assume the Christian ethic, it may be as well to summarize what I understand by the Christian axioms:

1. It is assumed that we are not irresponsible idiots dancing in a meaningless void, but that the universe has a purpose, and that therefore there must be an authority behind that purpose, outside ourselves, and beyond all human authority. This authority we call God.

2. It is assumed that the qualities of God are those which have been recognized throughout the ages as the highest: truth, beauty, integrity, justice, mercy, generosity, love. Since these are the qualities of God they must be more powerful than error, deceit, greed, fear, or hatred, and will in the long run overcome them. They therefore have absolute validity.

3. The methods approved by God are those shown most clearly in the life, the teaching, and the death of Jesus Christ. Two assumptions are outstanding here: first, that every single individual is of value to God, and should be of value to his fellow-men, however depraved, afflicted, ignorant, or inexperienced that individual may be: second, that truth cannot be established by compulsion, nor error overcome by force, but only by persuasion and example, based on integrity (uprightness) and love.

4. That every individual is capable of response to good and has an impulse to follow the highest that he sees, but that he has a free choice as to whether he will or will not make that response. (Unless we believe that we have free will there is obviously little value in discussing ethical problems.)

5. That the ideal, the perfect, is not something asymptotic to the real, to be aimed at but never achieved; rather it is a state that coexists with reality, a theoretical curve on which the real points will lie if we carry out the right experiments and do them correctly. The corollary of this, of course, is that *unless* we carry out the right experiments our results will not even approach the ideal curve, except fortuitously.

It may be added that what the Christian aims at is the right relationship of all men to God, a state in which they voluntarily cooperate with God in His purpose. In this connection it may be relevant to quote Sir Arthur S. Eddington, who wrote:

"In the case of our human friends we take their existence for granted, not caring whether it is proven or not. Our relationship is such that we could read philosophical arguments designed to prove the non-existence of each other, and perhaps even be convinced by them—and then laugh together over so odd a conclusion. I think it is something of the same kind of security we

[1] This may seem to be too facile; but I suggest that those who disagree with me should attempt the discipline of putting down on paper a statement of those beliefs which they regard as fundamental to their religion and therefore to their way of life, and should replace my summary by their own.

should seek in our relationship with God. The most flawless proof of the existence of God is no substitute for it, and if we have that relationship the most convincing disproof is turned harmlessly aside. If I may say it with reverence, the soul and God laugh together over so odd a conclusion."

This rather lengthy introduction is necessary before we can even frame our ethical problems and hope to indicate the answers. Professor Bart Bok, in pamphlet No. 3 in the series "Rights of Man," published for UNESCO, has said that it is the duty of every scientist "to examine searchingly the meaning and purposes of the work that he or she is performing; and when in the employ of others, to enquire into those purposes and to evaluate the moral issues that may be involved: to promote the development of science in the ways most beneficial to all mankind and to exert his or her influence as far as possible to prevent its misuse."

RELATION OF CHRISTIAN ETHIC TO CONTEMPORARY SCIENCE

What then is the duty of a science teacher toward his students? Of a scientist in relation to his work? Of either teacher or scientific research worker as a citizen of his own country and of the world? How far is the scientist responsible for the use to which his teaching or his work may be put? It is clear that all skill and all knowledge may be put to wrong use. A baby has to learn that his teeth may be used to bite food but not to bite other people. Language may be used to inform or to deceive, arithmetic for fraud or for honest bookkeeping. No teacher of primary school subjects can look at a bookstall, I should think, without wondering whether it is right to teach children to read and write, seeing that when they grow up they read and write such rubbish. Tools may be used to construct or to destroy but unless we wish to remain in a completely uncivilized state we must have them and face the risk of their misuse. Where does our responsibility as scientists begin and end? I think I can answer that best by means of an example, which may seem facetious but which contains, I believe, some profound truths.

Before the First World War there was a murder case in England which excited considerable interest. I can just remember it. It was called the "Brides in the Bath" case, and concerned a man who "married" a succession of middle-aged women with a little bit of money and then, after the honeymoon, arranged that they should accidentally drown while having a bath. His mistake, of course, was in not varying his method; some intelligent person with a long memory linked up the inquests. Now the point is this: baths are good things and so is water. By no stretch of imagination could the plumber or the officials of the Water Board be held responsible for these tragedies. *But*, if the intending murderer had gone to a plumber and had said to him "Look here, old man, I want to get rid of my wife; and it seems to me that it would be a good idea to drown her while she is having a bath, only unfortunately our house *has* no bath. Will you install one for me?" Then, if he did, the plumber would certainly, by English law at least, be an accessory before the fact and equally guilty of murder, even though he was doing nothing but his ordinary work.

The *risk* that one's work, though good in itself, will be misused must always be taken; but responsibility cannot be shirked if the known *purpose* of the work is criminal or evil, however ordinary the work itself may be.

This problem arises most acutely in the case of scientists working for firms or government departments engaged in research and development for military purposes, let us say in the USSR and the USA respectively. The question divides itself, as I see it, into four parts:

THE PROBLEMS OF MORALITY PRESENTED TO SCIENTISTS

1. The scientist must make up his mind whether international or civil war, either offensive or defensive, (and especially the retaliatory kind of defensive warfare,) is in accordance with the ethic chosen as the basis of his of his way of life. If not, then no considerations of expediency (justification of means by supposed ends) should keep him in his job. He may, however, be told that the object of his work is not war but the maintenance of peace through strength; the strength of his own nation and her allies, relative to those who are suspected of an intention of aggression. He must, in this case, recognize that he is participating in a gamble; a gamble based on fear, suspicion, and threats; a gamble which, if it succeeds in maintaining peace for a generation, does so at the expense of a young generation trained in the ways of war; a gamble, which, if it fails, must result in war itself. He must recognize that the fears and suspicions are quite certainly felt on both sides, and that his opposite number is facing his own problems. And he must decide his actions in the light of his own fundamental beliefs and not leave them to be decided by others on his behalf.

"The Root of the Matter . . ."

"There are certain things that our age needs, and certain things that it should avoid. It needs compassion and a wish that mankind should be happy; it needs the desire for knowledge and the determination to eschew pleasant myths; it needs, above all, courageous hope and the impulse to creativeness. The things that it must avoid and that have brought it to the brink of catastrophe are cruelty, envy, greed, competitiveness, search for irrational subjective certainty, and what Freudians call the death wish.

"The root of the matter is a very simple and old-fashioned thing, a thing so simple that I am almost ashamed to mention it, for fear of the derisive smile with which wise cynics will greet my words. The thing I mean—please forgive me for mentioning it—is love, Christian love, or compassion. If you feel this, you have a motive for existence, a guide in action, a reason for courage, an imperative necessity for intellectual honesty."

—Bertrand Russell
The Impact of Science on Society

2. It may be, however, that he has a wife and family. Ought he to allow his private scruples to affect them adversely? If he believes that the Christian ethic (or any other) requires him to face evil not by force but by suffering, ought he to involve others in that suffering, especially if they do not share his views? This problem must, however, be faced by the man who conscientiously takes part in war preparations as well as by the man who refuses to do so. No one has any excuse after two world wars for deceiving himself into thinking that war protects the weak. On the contrary, the weak and innocent suffer in their millions. If a man and his wife both suspect each other of an intention to murder the baby, and go around, armed with revolvers, determined to prevent it, the chances are that they will not only kill each other, but the baby, the cat, and the canary, too. And even if they do not, their married life will hardly be a happy one. The world today is desperately unhappy; personal problems are only part of the whole world problem, and should not dominate it.

3. Our hypothetical scientist may, however, be a very good democrat and may believe, therefore, that he is bound, whatever his personal views, to carry out experiments demanded by his democratically elected government, and financed, and presumably approved, by the majority of his fellow-citizens. If he is a convinced Communist (or a Nazi) he will no doubt feel equally obliged to obey directions, whatever his private qualms. But in the trials at Nuremberg, this excuse was not accepted as valid; men have a duty to humanity, and the Christian in particular owes allegiance to God before his government. True democracy recognizes this, and permits the man who has a genuinely conscientious scruple to refuse work which he believes to be contrary to the purpose of God and therefore injurious to mankind as a whole. Moreover, a truly democratic country is one in which the government not only permits opposition, but welcomes it; in which policy is modified by responsible and constructive criticism, and in which the man with ideals stands by them knowing that in so doing he serves his country best.

4. Apart, however, from deciding whether the work on which he is actually engaged is, or is not, contrary to the purpose of God in the world situation as it is, the scientist should, I suggest, consider whether he is *best* employed in that work. There are, according to the UNESCO booklet *War-Handicapped Children*, 250 million children in the world today who are starving; millions who have no homes, who are ill-clad, who lack education. There is no sense in framing high-sounding declarations about human rights, and especially about rights which are "without distinction of any kind, such as race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status,"[2] unless we are concerned with implementing those rights. It has been rightly said:[3] "Before we try to teach the children of the world about brotherhood and the rights of man, we must feed, clothe and care for them. It is useless to talk of democracy to a starving child. If, however, he is fed and given clothes and a home, these things will teach him something about brotherhood."

The writer of the first Epistle of John put it very succinctly: "who so hath this world's goods, and seeth his brother have need, and shutteth up his bowels of compassion from him, how dwelleth the love of God in him?"

If, as we are responsibly told, the real problem before the world is starvation, a problem which cannot but be accentuated by any diversion of intelligence, money, and materials toward non-productive ends, ought scientists to work on non-productive applications of science?

Apart from the purpose of their actual work, however, scientists may be expected to be concerned about the conditions under which they work. In particular, the question of secrecy should be examined, not as a matter of expediency, but in relation to fundamental ethics. The early Fellows of the Royal Society were instructed to direct their studies "to the glory of God the Creator, and the advantage of the human race." If these two objects were both kept in mind, the question of withholding information from publication would be seen in right perspective. It may be that some information should be withheld, but in that case, should it have been sought?

Finally, scientists need to consider whether they have any special contribution to make to the solution of the world's problems, apart from their specialized technical knowledge. Some scientists believe that they have not, that they should stick to their laboratories and not meddle with social and political problems for which they have not been specifically trained. On the other hand, the common man sometimes has more common sense than the expert, and politics especially should not be left wholly to the politician. At least, as Theodor Rosebury points out in *Peace or Pestilence*, the scientist is trained to admit his mistakes, and it would be as well if the world's statesmen could sometimes do the same thing. I believe that scientists and teachers of science, by virtue of their very training, have an essential contribution to make, as citizens, to the creation and maintenance of the conditions under which human rights are observed and peace can flourish.

The most important thing, however, is that every scientist should feel a sense of personal responsibility, not necessarily for the mess in which the world is now, but a responsibility to think out his fundamental axioms and the system of ethics that he builds up on those axioms, and then a responsibility for attempting, through personal decisions and personal actions, to make the world the kind of place he knows it ought to be.

[2] Universal Declaration of Human Rights, U.N., 1949, Article 2.

[3] Lake Success, September 26, 1948.

Concern for Man

"Concern for the man himself and his fate must always form the chief interest of all technical endeavors. Never forget this in the midst of your diagrams and equations."

—Albert Einstein

HOW MUCH IS LEFT IN THE HAT?

RICHARD L. MEIER

ONE of the most disturbing elements in the contemporary American social attitude is a blind, almost childlike, faith in the power of science.

If an obstruction to economic progress should appear, if a super-weapon to demolish the enemy is needed, or a super-defense for "absolute" security is lacking, the scientists and engineers are called upon to deliver.

"Give them a few years and the 'impossible' will all be worked out," is commonly heard from the public administrators responsible for planning. Equivalent assertions are almost as prevalent upon the nation's campuses. Scientific progress now seems to be a royal road to wish-fulfillment, so far only slightly tinged with fear and resentment. The public image of the social role of the scientist for the present seems to be that of a quizzical magician who continues to pull out of a hat (or test-tube) one marvel after another. Sometimes this magic fulfills a long-felt want, often it is merely a curiosity. But few have inquired into the dimensions of the hat, or into the natural limitations of the technique.

In a private conversation with an economist about the prospects for cheap power, the economist pointed out that in 1900 it took about 8 lbs. of coal to generate a kilowatt hour, in 1915 about 4 lbs., in 1930 about 2 lbs., and in 1945, only 1 lb.; therefore in 1960 it should require only a half pound! When it was pointed out that this would violate the Second Law of Thermodynamics, that difficulty was breezily waved aside. The conception that there are limitations to possible solutions of physical and biological problems to which man must adapt his society and his behavior has been largely lost, and will not easily be re-established.

This implicit faith in science and the diligence of the technologists who are exploiting it is nowhere more evident than in the plans for world development. Nowhere is the illusion of supernatural prestidigitation more tragic than in some of the hopes being raised for the poorer and more retarded areas of the earth. Today no complete plan for providing a universal minimum adequate standard of living can be projected for areas containing a total of a billion people—either the resources are lacking or the appropriate techniques do not yet exist. But many take for granted that these difficulties will be resolved, and they confidently go ahead, making commitments to spend money, tinker with the economy, and arouse hopes in simple peoples. A necessary (but not sufficient) condition for success in these directions is that "science" provide adequate answers for planning dilemmas within the next decade or two.

How great such expectations are may be judged by some estimates of world needs. Assuming about a threefold population increase before a demographic stabilization occurs (this figure is certainly a minimum) the world society needs methods sufficient to supply 5–8 times as much food, 7–10 times as much shelter, 10–15 times as much energy, and 10–20 times as much communications as the world produces today.

This must be done in the face of declining reserves of ores and fuels, the lack of new virgin soils, and the continual loss of soil nutrients in many locales. Clearly, these are not modest wishes. If scientists are to cope with them they will have to emphasize lines of inquiry which offer potentialities fully one or two orders of magnitude greater than those now in effect. Will the magician's hat, the dimensions of the accessible universe, permit this multiplication of demand?

The articles which follow indicate that certain rather radically new directions of research may just manage to provide the minimum needs. Little more than that can be envisioned at present.

If these new inquiries are successful, the great-grandchildren of those who are alive today in the world may not have beefsteaks, but they can have nutritionally balanced protein. They may not have a private automobile, but they can have some mobility. Their homes may not be spacious, but can be comfortable. Many of the values now associated with village life will have to be abandoned. These and many other adaptations will be required if the potentialities of science are to be realized to the extent that no community need starve or freeze.

Today, research should be organized and carried at least to the point where scientists can say whether the popular expectations are fulfillable, and at what cost. That is really a minimum responsibility of scientists. It should lead eventually to a greater realism in this sphere on the part of other educated members of society.

In continuation of the discussion of world population and resources, begun in our April issue with articles by F. W. Notestein, D. A. Fitzgerald, and K. Sax, we present in this issue a series of articles dealing with some more specific aspects of this all-important problem. This symposium was prepared by Richard L. Meier, Assistant Professor in the Program of Education and Research in Planning at the University of Chicago. Dr. Meier's concern with the problem of balancing world population and world resources has brought him to the conclusion that while no insurmountable difficulties threaten this balance from the side of metal and other inorganic raw materials, the question of adequate food supply cannot be dismissed with an easy reference to science being able to achieve the seemingly impossible. He brings this warning forward in a vigorous form in the brief article which opens the symposium.

CULTURE, TECHNOLOGY, AND POPULATION CHANGE

IRENE B. TAEUBER

In this article, Irene Taeuber, of the Office of Population Research at Princeton University, points out some consequences of population pressures in many areas of the world. She believes that the cultural patterns of the people of these areas must be analyzed in order to resolve this demographic imbalance.

THERE is a new orthodoxy concerning demography today. It says that while an imbalance between population growth and resources exists in wide areas of the globe, it should not cause undue alarm, since industrialization and urbanization will initiate a decline of the birth rate and thus restore the balance of births and deaths.

This is comforting theory but unrealistic demography for the next few decades. The combination of technological advance and cultural *laissez-faire* that prevails now tends to accentuate rather than to resolve the imbalance between fertility and mortality. The contemporary demographic maladjustment, like the growth of populations under the colonialism of the preceding period, is an unplanned consequence of economic development and medical progress. With these two forces operating in the framework of a culture with humanitarian ideals, there appear to be no feasible alternatives to modernization processes that create long-run difficulties almost in direct ratio to the resolution of short-run problems of health and economy.

While technically, almost anything is possible in changes in economy, mortality, and fertility, in fact, economic transformation is difficult and scarcely able to keep pace with the sharp reduction in mortality likely to accompany its initial stages; while high fertility remains inviolate in indigenous and Western thinking alike. This has led to rates of population increase beyond those regarded as probable even a decade ago.

Ceylon's modernization program involved the settlement of Sinhalese families in the formerly malaria-ridden northern part of the island. It was planned to settle some ten thousand families each year for five years. The utilization of DDT for mosquito control reduced mortality from malaria and other insect-borne diseases, so as to bring the death rate from 21.2 per 1,000 population in 1944–46 to 14.3 in 1947, 13.2 in 1948, and 12.6 in 1949. The recorded birth rate was 37.4 in 1944–46, and fluctuated around 40 in the succeeding years. The result was that the rate of natural increase, which had been 1.6 per cent in 1944–46, has risen to 2.5 per cent in 1947 and 2.7 per cent in 1948 and 1949.

Skepticism concerning the achievement of a balance between economy, mortality, and fertility at adequate living levels, may seen quaint at a time when the knowledge already available and the technological processes likely to come induce one to think of the future optimistically. The basic difficulties are twofold:

1. Physical, economic, political, social, and psychological factors produce critical differences in the speed at which the various segments of society are being, or can be transformed.

2. Resistances to planned reduction in fertility probably exist in all cultures; they are inherent in the ideological basis of the diffusing culture of the West.

Present levels of knowledge and technology are such that in theory, they should permit a rate of economic expansion far higher than that of population increase and thus yield a period of relative freedom during which cultural forces could be directed toward a transformation of family institutions and readjustment of reproductive mores. Grandiose economic plans proceed through human intermediation, however, and achievements are halting in the initial period. Three years ago there were blueprints for the production of all the fats and oils the United Kingdom needs from the tsetse-infested dry lands of Eastern Africa. The Bantu responded admirably to mechanical training, but the man who had been so carefully trained to run the bulldozer would frequently send his untrained friend as substitute—conforming to the ancient practice of African laborers—with results catastrophic for bulldozer, friend, and groundnuts production. Slow development in agriculture and in industry appears more feasible than the multi-billion dollar reclamation of the valley of the Amazon or the irrigation of the Sahara with waters of the Mediterranean—but slow development leaves high fertility largely unaffected and is unlikely to increase production more rapidly than population over any considerable period of time. If fertility remains outside the domain of planned social action the demographic consequence of technological advance may be only a quickening of the speed of the treadmill, with an increased likelihood of larger social cataclysms.

CULTURE CONFLICT, INTERNAL AND EXTERNAL

Current difficulties are the culmination of a process of accelerated growth that has accompanied the penetration of the cultures of the West into the areas where military and economic technologies were less advanced. In any culture, and at any rate of economic expansion, however, the demographic hazards to the achievements of welfare goals must increase as the difference between fertility and mortality widens. Rates of population increase, such as those that now exist in Ceylon, cannot continue indefinitely in a world of finite economic possibilities, and they cannot be ended except by an increase in the death rate

This article is based on a paper presented at the Annual Meeting of the Population Association of America, Princeton, New Jersey, April 29, 1950.

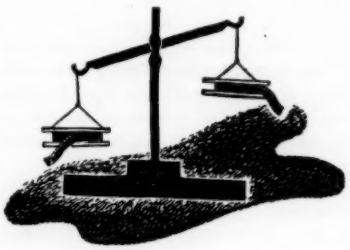
or a decrease of the birth rate. If we reject the former as a solution, we have no alternative but to choose the latter.

However, if we choose the reduction of the birth rate as the desired solution, we must realize that we are aiming at a rapid social change in a sphere of human life where change is opposed by age-old resistances and lethargies, where scientific research leads to scientific publications but not to social action.

The reasons for the inviolability of the pattern of continuing child-bearing lie partly in the social institutions and the accepted basic values of ancient agrarian cultures, partly in the contradictions which exist within our own civilization between the inherited values and contemporary motivations in family relations and reproductive behavior. The original culture of the West was well adapted to economic and demographic expansion. Its religion has derived from an ancient agrarian society where many children were essential to group survival and profitable to the individual family. Early marriage and frequent conceptions were "natural," for few continuing problems of overpopulation could exist where epidemics, famines, and physical insecurity increased the hazards of an already perilous life. The balance of a high and only slightly controlled fertility with a fluctuating mortality permitted not only survival but alternating contractions and expansions of populations as economic and political conditions changed. Given favorable environmental conditions and the invention or adoption of new techniques of agricultural utilization and political organization, peoples with such an automatic balance of deaths and births would literally inherit the earth. In fact, this is the type of balance that had evolved in all the cultures whose peoples are so numerous today.

There had been other types of population balances; for fertility was everywhere and at all times subject to some limitation, whether through institutional regularities, prescriptions or taboos, or the direct actions of individuals. The only requirement for survival was that fertility be sufficient to equate the production of new life to the destruction of the old. In some areas, particularly those of limited resources and relatively few environmental hazards, a fertility which made numbers superabundant was a hazard to survival equally as great as a fertility which was inadequate to replace numbers. And so among many peoples, but obviously not those who became the progenitors of nations now counting tens or hundreds of millions, the balance of births and deaths had involved in the past substantial controls of fertility.

The initial consequence of the contact of Western and other cultures during the centuries of discovery was doubtless a rise in mortality in the new areas penetrated by Europeans. Dis-



ease, disintegration of established order, and guns—these were the first gifts of the West to the areas now called underdeveloped. Political stability, economic development, and public health came much later. The Tasmanians virtually disappeared, as did many small groups of the Southwest Pacific and the American continent north of Mexico. The combination of disease, slave-trade, internal disorder, and cultural disorganization is believed to have produced decline of population all over Equatorial Africa.

Depopulation and extinction were not the fundamental reactions to the contact with the expanding West, however. The more typical long-run reaction to the partial diffusion of Western culture and one-sided economic development that had accompanied the integration of other areas into the Western nexus of production and trade, was population increase, slow and irregular at first, gradually stabilizing and quickening. By the end of the interwar period, rates of natural increase throughout most of the non-industrialized world approached or even exceeded 1.5 per cent per year. In the more efficiently exploited colonial areas, such as Taiwan and Korea, rates of increase already then exceeded 2.5 per cent per year.

In the early centuries of political and economic penetration, rates of population increase were higher among Western peoples than among those whom the West was utilizing. On the face of it, there was one and the the same population problem all over the world, the one that Malthus saw: increasing product, declining mortality, high fertility, ending with a population increase that would eventually negate the economic amelioration that had been achieved and restore mortality to the level necessary to carry off the surplus people.

Actually, however, there were critical differences between the indigenous growth of population in the industrializing West, and the induced increases in the dependent agrarian areas. Europe's geographic and economic expansion provided employment opportunities for her increasing manpower at the same time that it created the conditions of working, living, and thinking that eventually lessened the rate of increase in that manpower. The slow decline in fertility was largely an unintentional by-product of geographical redistribution of population and a cultural transformation that were themselves unplanned. City living and its opportunities for improving social status stimulated a widespread reduction of family size. The value systems of the elite tended to remain those of the ancient period, however, so that there appeared throughout the West a fundamental and increasing divergence between expressed values and the behavior of the people in the sphere of marriage, family, and child-bearing.

THE ECONOMIC, CULTURAL, AND DEMOGRAPHIC TRANSFORMATIONS

Outside the industrializing cultures of the West and Japan, the economic, cultural, and demographic transformations carried within themselves no automatic solutions to problems, either of manpower utilization or of population growth. There were no empty Americas to take up excess population, and the limited land frontier areas that did exist were settled in the traditional agrarian pattern, leaving as permanent heritage only an extension of the area of poverty. This agrarian economic development barred the industrialization, urbanization, mass education, and *de facto* democratization that were so intimately associated with the secularizing values and declining of fertility in the West. Thus growth occurred in the absence of those abundant opportunities that could have sustained it painlessly for long periods of time and, more significantly, without that particular constellation of economic, cultural, and psychological forces that could have terminated it naturally through declining fertility.

In the period before the Second

World War, demographers were becoming aware of the seriousness of the problem of population increase, particularly in the crowded river valleys of monsoon Asia, the valley of the Nile, and the dusty lands of South Africa. Many of the world's peoples appeared caught in a paradoxical dilemma, for population density, rates of increase, and hence the present and future demographic difficulties, increased with the efficiency and the humanitarianism of the political administration and the progress of subsistence production. In teeming Java, the Dutch were preoccupied with the race to balance production and population increase. An Indian Famine Commission report of 1943 cited an earlier report of 1880 to indicate both the antiquity and the increasing gravity of the problem of slowly increasing food production and multiplying people. Areas which once exported rice were becoming rice-importing; only the great deltas of Southeastern Asia remained as potential sources for the rising rice requirements of the expanding population of the Asian continent. The accelerated natural increase of the cultivator nations themselves presaged a time when the fertile river basins of the Mekong and the Menam would become as overpopulated as those of the Tongin and the Whang-Ho.

Superficially all was calm. Famines and epidemics had been conquered in the colonial areas, death rates lowered, and per capita production increased. A West which moved toward planned parenthood, equality of status for women, and equality of opportunity for children judged its success in backward areas by the population increase. The Mandates Commission of the League of Nations accepted a high rate of population increase as proof of benevolent administration, and concentrated its attention on the causes of the continuing depopulation of the tiny Micronesian island of Yap.

The social scientists of the world saw the political, economic, and social problems of colonialism and economic backwardness, but they barely noted the demographic consequences of the partial diffusion of segments of Western culture into the East. In fact, perusal of the literature leads one to the conclusion that the adoption of the policies approved at that time by social scientists would have perpetuated, if not widened, the gap between fertility and mortality. The preservation of indigenous cultures was an unquestioned value; changes should be consistent with those cultures and they should occur gradually. Agrarianism was most consistent with indigenous life; industrialization and urbanization produced changes referred to in such invidious terms as detribalization. All public health activities were assumed to be to the good and any reduction of mortality or decrease of disease a sign of progress. There was to be political democracy, but it was to come gradually through the elevation of native life by exposure to a few years of education in the vernacular. There was nothing but silence about the role of family institutions and agrarian attitudes that sustained the high fertility and thus created a host of almost insoluble political, economic, and social problems.

The greatest problem of agrarian areas and the greatest hazard to their future industrialization was thus barred from research. No attempt was made to plumb the depth of the cultural traditions that made reproductive behavior sacrosanct. Biological and chemical research that might have led to the discovery of techniques of control adapted to use in peasant societies was left undone. It never became fashionable to inquire into contraception. Even congresses of tropical medicine and medical journals of areas of high density largely ignored fertility as a direct cause of death among women, and an indirect cause of mortality in the total population because it produced people for whom there was no function in the existing economy.

World War II unleashed nationalism in the world's newly developing areas. Its consequences included independence, disorganization, revolution, the onward rush of the new imperialism of the Soviet Union, and war. The demographic future of specific areas may have been altered by this national awakening, but the broad outlines of the demographic difficulties remained unchanged. If colonialism of the left replaces that of the right, the situation will be no less acute. There is no basis for assuming that this change will lead to a more rational search for solutions. The demographic ideology of communism holds that numbers should increase, and on this dogma it appears adamant.

Thus, now, as before, excessive population increase, caused by economic development, threatens individual welfare and political stability. The fundamental maladjustment is neither insufficient subsistence expansion, nor excessive mortality reduction, but a fertility that has become superabundant with improved life expectancy. And yet, there still is a general taboo on the research in a field crucial for the determination of feasible action. It has to be concealed in the anonymity of projects directed toward the officially recognized respectable goals of economic amelioration or health improvement. In the individual countries where the imbalance of births and deaths is most acute such research subjects as determining the attitudes of women appear remote indeed, as contrasted to the urgencies of the present. Then, too, there is the naive ideology of expansionism that identifies numbers of men with the power of armies and the stature of nations.

In this situation the role to be played by the science of the West remains nebulous. The limited action that would otherwise be feasible is frustrated by the inconsistencies between inherited ethics and actual contemporary practice of the West. In Japan, the United States has asserted that both research and action in the field of fertility control is the prerogative of the indigenous people. In the Trust Territories of the Pacific, we subsidize research to ascertain the causes of too slow a growth or actual decline of population, and regard its rapid increase as an indication of progress. Thus, if we interfere at all, we do it in line with our accustomed values, oblivious to the difficulties bound to arise when teeming Micronesians, living longer and healthier lives, will face the problems of subsisting in simple agrarian economies on the tiny volcanic islands and the coral atolls of the Southwest Pacific.

I am not suggesting that we withhold our concepts of democracy and equality for all men, nor our life-producing and life-saving technologies in the fields of agriculture, nutrition, and health. To do so would be quite inconsistent with our fundamental ethics and our humanitarianism. I am suggesting that we analyze our own cultural patterns to discover in cooperation with the peoples concerned means to resolve the demographic imbalances that now exist in so many areas. American action alone is not sufficient, for American efforts to reform other peoples are likely to be received in rather unfriendly fashion by them. The science and the techniques we have to offer, both biological and social, must be used to develop research and action programs adapted to meet the special needs of the people for whom they are planned.

PROBLEMS OF FOOD PRODUCTION

EDGAR TASCHDJIAN

Dr. Edgar Taschdjian, a Viennese of Armenian ancestry, now with Loyola University in Chicago, is a biologist who has worked on pure and applied physiology and genetic projects in Europe, Asia, Africa, and South America. He began his career as assistant to Dr. Tschermak-Seysenegg, the rediscoverer of the laws of heredity, and in recent years has done several papers on radical alternatives to present agricultural methods.

WHY INCREASE FOOD PRODUCTION?

THE purpose of efforts to increase world food production is to raise the standard of nutrition everywhere and thereby to improve the quantitative and qualitative development of the human race. There might conceivably be another purpose which would probably not be admitted as freely. A country able to satisfy the world's hunger would have at its command a powerful means to gain and keep the allegiance of the nations. While the atomic bomb may be the most powerful weapon so far devised to win a war, a means to solve the hunger problem could become the most powerful instrument to keep lasting peace—if it were not abused for the sake of power politics.

D. A. Fitzgerald thinks that, provided there is some improvement everywhere, people will be satisfied and political stability will be assured.[1] This view may have been legitimate before the establishment of modern communications; at present its validity will probably depend on the rate of improvement. Alternatively, one might say that if the aim of nutritional improvement is peace, the price of peace is justice.[2] While justice does not require that we provide everybody with free meals a la Brillat-Savarin, it carries a moral obligation to provide everybody with the essentials necessary for the upkeep of life. In social planning, the purpose of the plan must be clarified before adequate means to achieve it can be selected.

THE MEANS

Food may be obtained (*a*) by collecting (hunting and fishing), (*b*) by *agricultural production* in the widest sense of the word, including fish breeding and wildlife conservation, (*c*) by production through non-agricultural methods. The first alternative is suitable only to rather primitive social conditions, although we are still at that stage with regard to deep-sea fishing. As regards agricultural food production, the writer has analyzed the different factors which limit food production on a world scale in a publication[3]

[3] E. Taschdjian, "The Hunger Problem," *Scientia* (November 1949), 209.

Taking Stock

"The most important new fact of the past half-century is, I believe, that the human species has for the first time in its history begun to take stock of its position in the world. I am sure that many people will disagree: some will plump for the emergence of communism as a major force; others for the control of atomic energy; others again for the beginning of international organization. But I still maintain that in the long run this world stock-taking will prove to have the greatest importance."

—JULIAN HUXLEY
from article in Harper's Magazine

which is not readily accessible. Since there still seem to be a number of people in responsible positions[1,4,5] who believe that the problem can be solved on a global scale by agricultural methods, it may be worth while to summarize here the main points of that analysis.

There are external and internal limiting factors in agricultural food production. The first may be classified as follows:

a) The limited land area on earth: Of the total land area of the globe, *only 7–11 per cent is suitable for agriculture.*

b) The limited *water supply* of agricultural land caused by the fact that about one-third of the earth's surface receives less than 10 in. of precipitation annually, and an additional third only 10–20 in., quantities which make the economical use of large quantities of fertilizers impossible. Unfavorable distribution of rainfall and erosion accentuate this limitation. Erosion increases with an increase in the intensity of cultivation. Conservation measures can improve the quality of food, but not increase the number of calories of food energy per acre.

c) The limitation of *draught power* necessary to plow and till the field restricts the economic possibilities of food production. In most areas, increase in draught animals can be

[1] Dennis A. Fitzgerald, "World Needs and Resources," *Bulletin of the Atomic Scientists*, VII (April 1951), 102–05.

[2] Committee to Frame a World Constitution, Preliminary Draft of a World Constitution, *Common Cause*, I (March 1948), 329.

[4] Elizabeth E. Hoyt, *Freedom from Want: A World Goal*, Public Affairs Pamphlet, No. 80, 1943.

[5] Clarence Enzler and the Subcommittee on Agriculture, *Can the World Feed Itself?* Pamphlet No. 45, The Catholic Association for International Peace, Washington, 1950.

achieved only at the expense of acreage devoted to human food.

d) Limitations due to *diseases, pests, and weeds:* The latter increases excessively the bill for cultivation of otherwise most favorable areas.

e) Limitations due to *lack of education* and consequent poor organization and low efficiency in farm management.

Apart from the above, however, there is another internal limitation of growth in higher plants. Even under the best conditions imaginable, a higher plant cannot be made to grow indefinitely at the same rate as in its initial stages of development, for it aims to achieve a definite form, and this can be reached only if some cells stop dividing, or divide slower than others. If this were not so, every plant would finally assume the form of a sphere. This internal limitation does not apply to unicellular organisms, which can go on dividing as long as conditions remain favorable.

On the basis of various estimates of possible increases in acreage, productivity, etc., made by Baker, Salter, and others,[6] the writer came to the conclusion that an increase in food output of 75–100 per cent is the maximum that can be achieved by agricultural methods. The effect of this increase will presumably be nullified within one hundred years by a corresponding growth in the earth's population.

The following passages from a recent governmental survey[7] show that the prospects for this country are not more cheering than for the rest of the world: ". . . it appears that the increased productivity of existing agricultural acreage, if added to the production available from new lands brought in by irrigation, drainage, flood control, and clearing, is likely to meet the nation's expanding requirements over the next twenty-five years by a rather narrow margin. . . . Full development of the production potentials will barely provide sufficient production to meet the requirements anticipated by 1975. . . . The soil conservation program, if effectively carried out during the next twenty-five years, can be depended upon to do no more than take care of the increased demands due to the correlative improvement in diet, insofar as that involves increased consumption of livestock products."

In other words, unless non-agricultural food resources are tapped by 1975, the American diet will have to decrease in quality by a drop in the consumption of livestock products and an increase in direct consumption of grain and other staples.

Food production by non-agricultural means may be achieved in the following ways:

a) HYDROPONICS

This method consists in the cultivation of crops in nutrient solutions. The plants are anchored on a raft or other suitable support, rather than in soil, and their roots float in the solution. Consequently, they have an abundant water supply and the yields per unit area may be considerably larger than in a field or garden in the same region. Growth is then limited by the supply of carbon dioxide and sunshine rather than by that of water. However, hydroponic crops are still subject to the internal, formal limitations inherent in all higher plants which we have discussed above. The usefulness of this method of cultivation is restricted to regions with an abundant supply of sunshine and water, and to high-priced crops.

b) UTILIZATION OF WOOD AND CELLULOSE

Of the earth's 36 billion acres of land only 2.6 billion are used for agriculture, while ca. 7.5 billion acres are in forests; for the United States the corresponding figures are 925 and 550 million acres respectively. In cereals, the relation of grain: straw varies from 1.3 in corn to 3 in rye. Some of the cellulose of straw is utilized by ruminants, through its decomposition in the cud by specific bacteria. In Germany straw and oat hulls have been used for the production of fat, with the help of a species of yeast. The claim was made that 5.5 kg of fat could be obtained from 100 kg of straw.[8] A mold, *Penicillium javanicum*, is studied for the same purpose by the Armour Research laboratories.[9] The Forest Products Laboratory, Madison, Wisconsin, has investigated the growing of fodder yeast on wood sugar produced by chemical hydrolysis.[10]

But so far, nobody seems to have investigated seriously the possibility of a biological decomposition of wood and cellulose, as a source of human food, although it is known that the protozoa living in the intestine of termites and wood roaches have this ability. It has been shown that these organisms can be grown successfully on artificial media.[11] It seems that further progress along this line will be dependent upon the successful development of a mechanical instead of a chemical method of producing fine dispersions of wood particles.

c) EXTRACTION OF NATURALLY OCCURRING VEGETAL AND ANIMAL PLANKTON FROM THE SEA AND FROM LAKES

Microorganisms floating in the water are called plankton. If they have the ability for photosynthesis, similar to the algae, we speak of phytoplankton; if they require organic nutrition, we speak of zooplankton. C. Juday, in 1943[12] estimated that the average amount of plankton in Crystal Lake was 45 kgs per ha (41 lbs per acre), while the maximum in Lake Waubesa indicated a "standing crop" of 966 kg/ha or 862 lbs/acre. A turnover once a month in this lake would give an annual yield of 2592 lbs/acre of dry organic matter. G. L. Clarke and O. W. Bishop found that the zooplankton varied in the upper layers of the sea from 0.45 to 1.12 cc per m^3.[13] Lohmann arrives at figures[14] indicating a plant production in the North Sea near Kiel of $10mm^3/m^3$ during February, (the month of minimum plant production) and of $350mm^3/m^3$ in August (the month of highest production).

On the basis of determinations made

[6] J. J. Spengler, "The World's Hunger-Malthus 1948," *Proceedings of the Academy of Political Science*, XXIII (January 1949), 69.

[7] President's Water Resources Policy Commission, *A Water Policy for the American People*, U.S. Government Printing Office, Washington, D.C., 1950, pp. 160, 163, 166.

[8] Leonard J. Vinson, *Micro-organisms as Food, The Frontier*, Published by the Illinois Institute of Technology, March 1949, p. 10.

[9] *Ibid.*

[10] *Ibid.*, p. 9.

[11] William Trager, "The Cultivation of a Cellulose-Digesting Flagellate, Trichomonas Termopsidis, and of Certain Other Termite Protozoa," *Biological Bulletin*, Vol. LVI, No. 2, April 1934.

[12] Chancey Juday, "The Utilization of Aquatic Food Resources," *Science* (1943), 456–57.

[13] George L. Clarke and D. W. Bishop, "The Nutritional Value of Marine Zooplankton with a Consideration of its Use as an Emergency Food," *Ecology*, Vol. 29, No. 1, January 1948.

[14] Sverdrup, Johnson, and Fleming, *The Oceans*, New York: Prentice-Hall, p. 930.

by H. H. Gran and T. Braarud,[15] the writer has calculated the content of phytoplankton in the Atlantic to a depth of 25m as an average of 111.8 g/m³ fresh weight, (assuming the average diameter of the organisms to be 40 micron, its density 1.0, and its shape more or less spherical). The variations, however, are exceedingly large, and the maximum is as high as 1230 g/m³. Adding to the above average the amount of zooplankton found by Clark and Bishop (average 78 cc/m³) and assuming for it likewise a density of 1.0, we arrive at a crop of mixed, fresh plankton of 190 g/m³. The dry weights vary between 8 and 15 per cent of the fresh weights.

In this connection it is worth while to rectify an erroneous statement which is made repeatedly in discussions of algal food, to the effect that plankton is abundant only in cold, arctic waters. This is correct only of the surface layers, since in regions with little sunshine the phytoplankton has the tendency to accumulate near the surface where conditions for photosynthesis are favorable. But Riley has shown[16] that although the quantity of plant pigments (which can be used as a measure of the amount of plant life) in the surface waters was three times as great in the North as in the South, their total amount in the vertical column under the unit surface area was considerably greater in the Southern than in Northern waters.

As regards the possibility of harvesting the plankton, Juday, on the basis of plankton density in Lake Waubesa, and assuming the use of a clarifier centrifuge capable of processing 1.5m³ in 2 hours, estimated that it would take 200 hours to extract the daily food energy requirements for one person. There are, however, industrial clarifiers on the market with a capacity about 25 times greater, (up to 6000 gallons per hour). On the basis of Juday's estimate, the daily requirements for 3 persons could be extracted by one such centrifuge in 24 hours.

It should be mentioned, however, that since the bulk of the phytoplankton consists of diatoms containing a high percentage of silica, the edibility, digestibility and palatability of the crude plankton for humans is probably low. It would therefore probably require improvement by processing, possibly through feeding to fishes in salt water ponds[17] or through fermentative processes.

As regards the economic feasibility of the extraction of sea plankton it would depend on the amount and unit cost of the energy required for extraction, as well as on the price of the product. At present prices of food and energy it would hardly be economical, but if, during famine periods, a cheap source of energy could be made available, it may pay to attempt the extraction even though the number of calories of food extracted should be less than the number of calories of energy used in the extraction. It may, perhaps, be possible to obtain the required cheap energy from sea waves by means of a suitable wave motor, utilizing the upward component force of the wave, which has been found in one case to reach 11500 kg/m².[18] Measurements made during gales on the coast of Scotland have shown that the total force exerted by the waves reaches up to 600 lbs per square foot. The data available at present, however, seem insufficient for a reliable appraisal of this possibility.

"LIKE CAVIAR . . ."

At the suggestion of Dr. Alexander Bajkov, formerly of the U.S. Army Air Forces Aero-Medical Laboratory, Mr. Thor Heyerdahl took on his raft cruise, described in *Kon-Tiki*, from Peru to the Tuamotu Archipelago a plankton fishing net with which the party made a daily catch of five to ten pounds of mixed plankton. Four members of the expedition found plankton a great delicacy, since its taste, according to its composition, resembles either that of shrimp paste or caviar.

Mr. Heyerdahl said, "An apparently limitless source of food was plankton. More than once persons have starved to death at sea while sailing in strongly diluted raw-fish soup. If they had had a utensil for straining it, they would have found a nourishing meal in the thousands of tiny organisms which drift about near the surface of the sea."

d) FOOD PRODUCTION BY INDUSTRIAL PHOTOSYNTHESIS

Perhaps the most promising development in food production since the beginning of agriculture is the cultivation of the microscopic green alga *Chlorella* as an industrial process now studied at Stanford University. Estimates indicate that if and when engineering problems are completely mastered, commercial production might result in as much as 55,000 pounds of protein per acre, as compared with 880 pounds obtainable from soybeans per acre.[19]

The process is especially promising because it allows a reduction in harvesting costs to a level where they no longer count materially. On the other hand one has to emphasize here the limitations of the Stanford process, especially as regards its applicability to

[15] H. H. Gran and T. Braarud, "A Quantitative Study of the Phytoplankton in the Bay of Fundy and the Gulf of Maine," Contrib. of the Woods Hole Oceanogr. Inst. No. 69, *Journal of the Biology Board of Canada*, I (Canada Fisheries Research Board, 1934–35), 279–457.

[16] Gordon A. Riley, "Plankton Studies II, The Western North Atlantic," May–June 1939, *Jour. Marine Research*, II (1939), 158–59.

[17] Eli Schwartz, "Fish Pond Culture for Undeveloped Areas," *Land Economics*, XXVII (May 1951), 152.

[18] H. Blanck, *Handbuch der Bodenlehre*, Vol. 1, J. Springer, Berlin, 1929, p. 248.

[19] Paul M. Cook, *The Large-Scale Culture of Chlorella*, Stanford Research Institute, California, December 1949.

W. H. Pearsall and G. E. Fogg, "The Utilization of Algae for Industrial Photosynthesis," D.S.I.R. Food Investigation Memoir No. 659, *Food Science Abstracts*, XXIII (1951), 1–11.

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Chemical and Engineering News, April 16, 1951, p. 1505.

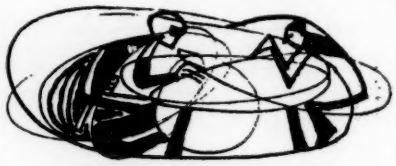
underdeveloped areas. The designs worked out at present require an industrial source of carbon dioxide, (while agricultural plants absorb carbon-dioxide of the air); a supply of fixed nitrogen, and a fuel—such as oil or coal—for spray-drying the harvested algae. Furthermore, it should be remembered that the high yields mentioned above have been obtained in contamination-free cultures; and although sterility may not be mandatory, the yields under non-sterile conditions would probably be lower. Whether skilled technicians necessary to establish and run such plants can be made available in underdeveloped areas may be an important factor in the applicability of the process. It is therefore worth while to discuss also other, simpler projects.

e) OPEN-AIR BATCH CULTURES OF MICROORGANISMS

So far, two promising attempts have been made to produce food in non-sterile systems. In Germany, open-air batch cultures of *Chlorella*, enriched in carbon dioxide by bubbling through them the flue gases from factories, are being investigated.[20] An attempt is being made to overcome contamination by keeping conditions optimal for the growth of *Chlorella* and by selecting highly resistant Chlorella strains. Even if this attempt proves successful, however, the application of such a method would be restricted to localities in which large quantities of carbon dioxide are available, i.e., to highly industrialized regions, and possibly to the vicinity of lime kilns.

Another method which seems better adapted for use in underdeveloped and famine regions, uses a green flagellate, *Euglena*, (or some of its relatives) instead of a true plant such as *Chlorella*. Euglena is an organism on the borderline between the plant and the animal kingdom. Imagine a man with a green skin, able to get his food by absorbing carbon dioxide and sunshine through his body surface, as well as to feed in the more orthodox way by decomposing organic matter in his intestine. Evidently, if both possibilities could be realized simultaneously, growth will be faster and similarly, quick growth of Euglena cultures requires not only carbon dioxide and sunlight, but also the supply of some organic carbon and nitrogen compounds.

On this basis, in Venezuela, sewage and soil decoctions have been used successfully to produce a "soup" which was well tolerated by consumers in doses of 400 cc daily, was palatable and had a very favorable nutritional effect.[21] If we remember that higher plants can avail themselves only of



that fraction of soil nutrients that is present in the soil solution, the use of soil decoctions seems the most obvious means of transforming food production into a mining process. It is also known that addition of fresh human urine has a surprisingly strong stimulating effect on the growth of mixed algal and euglenoid cultures.[22] Since both soil extracts and urine are available even in the most primitive areas, this method may be the most promising approach to the famine problem in such regions.

Euglena has the further advantage that it contains considerable quantities of starch, and could therefore provide a more balanced diet than Chlorella which contains very little carbohydrate when grown under optimal conditions. As regards harvesting methods, one has utilized in Venezuela the fact that the organisms settle at night at the bottom of the containers and that, after pouring off the liquid, one can scrape them from the walls into a thick suspension at the bottom. For day harvesting, a flotation process or a simple separator centrifuge could probably be developed without difficulty.

C. PROBLEMS OF ADJUSTMENT BETWEEN FOOD PRODUCTION AND FOOD CONSUMPTION

The formulation of a global policy aiming at the elimination of famine and thus at the adjustment between food production and food consumption raises a number of difficult problems. F. W. Notestein[23] has emphasized that population growth is not independent of the development of resources, but that demographic predictions presuppose a knowledge of the available (actual and potential) resources. Even the definition of what constitutes a resource will change with the development of technology.

As a matter of fact, however, we have not two, but three interdependent variables, namely, *a*) population size, *b*) resources, and *c*) organization of the population.[24]

That resource abundance is a variable and not a constant is evident, since the definition of a resource presupposes some known means of utilizing it; in other words, it depends upon the state of scientific and technological knowledge. But this, in turn, depends upon the historically determined organization of the population, as well as upon its absolute size. It would have been impossible for a small nation to develop the technical apparatus necessary for the development of the atomic bomb, so that uranium would not be considered as an "energy resource" for it.

On the other hand, the organization of the population depends as well on its size as on its resources. A philharmonic orchestra could not maintain itself in a village. We come therefore to the conclusion that the connection between population size, resources, and organization is a triple—or, if we consider each resource separately—a multiple correlation. This allows us to predict the population size corresponding to a given set of resources and a given organization only with a certain probability and not with absolute certainty, and the same holds for the reverse relations. How such predictions should best be carried out, remains to be determined.[25] But whatever method is used they all require the selection of certain so-called

[20] Meffert Stratman, "Brief Report on Research Work in the Field of Mass Cultivation of Algae." Carried out by the Kohlenstoff-biologische Forschungsstation E. V., Mimeographed Report, 1951.

[21] Private communication of Mr. J. Jorgensen, a biochemist connected with the leper institute near Maracaibo.

[22] Einar Naumann, "Die Massenzucht von nannoplanktischen Grünalgen als Futter für Wassertiere," *Abderhalden's Handbuch der biologischen Arbeitsmethoden*, 1920, Abt. 9, Teil 2, 2 Hälfte, p. 1787.

[23] F. W. Notestein, "The Needs of World Population," *Bulletin of the Atomic Scientists*, VII (April 1951), 99–101, 128.

[24] Amos H. Hawley, *Human Ecology*, New York: The Ronald Press, 1950, pp. 122, 173.

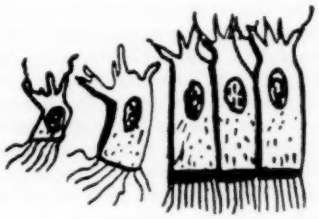
[25] Several methods are available, such as Isserlis' partial correlation ratio, Court's formulae for non-additive or joint causation, Sewall Wright's path coefficients, or Ezekiel's curvilinear regression surfaces.

weight functions expressing the importance attributed to the different variables. Abraham Wald has shown that the question as to what weight function should be chosen in such problems is not a mathematical or a statistical question, but involves non-mathematical considerations.[26] In other words, a resource has a different importance according to the purpose for which it is intended and the risks we are willing to take, and this importance therefore cannot be determined by purely objective criteria.

Another subjective and arbitrary factor is hidden behind the word "optimum," in the discussions of "optimal population" size. It depends on what is to be considered the best standard of living.[27] The decision to aim at such an optimum would be, of course, a purely rational decision. J. v. Neumann[28] has pointed out that the rules of rational behavior must provide for the possibility of irrational conduct on the part of others, and that if the non-conformist behavior of irrational individuals should prove advantageous for them, a rational policy may be a very questionable solution.

The same author has also emphasized[29] that any policy aiming at an equilibrium—in our case between resources and population—is by that very fact a static rather than a dynamic solution. I should not like to be misunderstood here. If we say that the development of humanity should be based on a dynamic rather than a static policy and if we emphasize that technology is a variable, this does not imply that it is not subject to limits inherent in the very laws of nature and of the human mind. In his introduction to this symposium, R. L. Meier emphasizes this when he says that even a magician cannot pull a rabbit out of a hat which is too small to contain a rabbit. If we may be allowed to paraphrase this, we might say, however, that the hat may vary in size. If, for instance, photosynthesis without living cells should become possible, which is at least conceivable, it would immediately put the food problem on a completely different basis.

When we speak of the stabilization of populations, we should also make it clear, especially to the non-technical reader, whether we mean a "natural" stabilization resulting from a narrowly limited supply of life necessities, or one resulting from voluntary restriction in procreation below that level. Evidently only the second would eliminate famine or other hardships. But then the question arises whether the restriction in the birth rate should be left to the individuals or whether it should be achieved by a global policy,



possibly one adjusted at certain intervals to the changing state of resources. In the first case, the over-all aim of stabilization would probably not be achieved. In the latter case it would probably be necessary to enforce conformism in order to stabilize the world population, at least for a certain period, at a given level; and the result, then, might well be something in the nature of Huxley's *Brave New World*. We might then find ourselves confronted with a choice of two evils, famine on the one hand and loss of freedom in the most intimate sphere of human life on the other. The question as to which of the two is preferable will probably be answered differently by different individuals and different ideologies. Perhaps different sections of humanity should be allowed different choices, provided they stick to them and accept the consequences.

The aim of this article was to point out problems rather than solutions, and this must be the apology for the inconclusive note on which it ends. If it stimulates thinking on the subject, its purpose will have been fully achieved.

[26] A. Wald, *On the Principles of Statistical Inference*, Notre Dame Mathematical Lectures, 1942.

[27] A. Hawley, *loc. cit.*, pp. 172–73.

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[29] *Ibid.*, pp. 44–45.

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THE LONG-TERM PROSPECTS FOR ESSENTIAL MINERALS

RICHARD L. MEIER

To what extent is the world's supply of minerals depleted? Will advances in technology be able to meet expanding world consumption of minerals? What mineral substitutes are available? Dr. Richard L. Meier of the Program of Education and Research in Planning at the University of Chicago examines these questions in the article below.

THERE have been many scares in recent decades, and subsequent reassurances, concerning the depletion of mineral resources which are essential to modern industrial societies. Many of these projections and prophesies of doom failed to take into account either new techniques of exploration or improved techniques permitting exploitation of lower grade deposits.

Nevertheless, the specter of complete exhaustion of certain reserves is a real one, and there are many ghost towns scattered about the hills and mountains to remind us that on a small scale it happens over and over again. Thus, a more realistic projection of mineral supplies to meet expanding world consumption must take into account the probable advances in technology both in the mining of minerals and in their utilization.

It must study the effects of higher costs, of reclamation of scrap, and of substitution of other materials. This procedure has been carried out for certain critical or strategic minerals, such as uranium and manganese, but a total picture has not yet been worked out. In its absence a rapid survey can bring to general attention the more critical problems in supply and future development.

Intuitively it is recognized that the few hundreds of millions of people who are relatively well off today have exploited the richer deposits and the higher grade ores over most of the earth's surface. Providing for five to ten times as many more persons will require a resource-development far greater than those numbers indicate. The possibility must also be explored as to whether some critical elements may be in totally inadequate supply—threatening a final frustration of the hopes for world development.

CONSUMPTION PATTERNS

The United States is a relatively self-sufficient economy maintaining a high standard of living. Consumption figures are quite complete for this area and give some measure of the demand for various minerals in a nation using modern technology. For the year 1948 trade barriers were not important, military requirements were relatively small, and the amount of exports amounted to considerably less than 10 per cent of the total consumption of the various minerals listed, so that the fewest abnormalities exist in the consumption pattern recorded in Tables I–V. They are to be compared with estimates for Asia (Table VI) for the same year in order to comprehend the difference between advanced and underdeveloped economies.

Perhaps the most significant of these tabulations is the first, dealing with the utilization of energy resources. The per capita consumption is astonishing, and disturbing to those who match the rates of depletion of these fossil fuels against the probable reserves.

These reserves should not be estimated separately any longer because the means of converting coal into the scarcer liquid and gaseous fuels are not only technically feasible but are very near to being economic. The United States economy is such that it is depleting its energy resources at a rate of perhaps 0.1–.2 per cent per year.[1] If the rest of the world were to consume energy at this rate the total supplies would vanish in a century or two even if allowances were made for the discovery of new deposits in poorly explored areas.

[1] The U.S. energy consumption per capita per day in the U.S. is about 150,000 Kilocalories.

However, long before such increases in consumption could be achieved, a period of rapidly increasing costs would be encountered due to the need to dig deeper for thinner deposits. The acquisition of fuel may easily become a serious damper upon world development.

How is the fuel used? It is not easy to break down current consumption into suitable categories but it appears that approximately 10 per cent is allocated to electric power production, 10 per cent to home heating and gas utilities, 12 per cent to the steel industry, 25 per cent to transport (about half of which is expended on the highways), 20 per cent to industry, and the remainder for export and miscellaneous uses. If present plans are carried out, the proportion devoted to electric power production will be doubled in the next few years, and this increase will very likely be accompanied by minor reductions in industrial and miscellaneous uses but will in general reflect an increase in over-all per capita energy consumption. Approximately 15–20 per cent of the energy is expended in obtaining the minerals themselves, and working them into ingots, billets, cements, and other materials ready for the manufacturing or fabrication stage. Thus, if a fuel shortage should develop there can be no simple cuts but a whole series of adjustments would have to be worked out.

Fortunately the metals picture looks less ominous. The most common metals in the earth's crust have, with few exceptions, become the principal materials of construction for machines and equipment. The costs of utilizing the inexhaustible, but somewhat lower grade, deposits of iron and aluminum ores are not very much greater than present costs (say 20–50 per cent added). This would not be true of lead and zinc, and perhaps even copper, because the lower grade deposits tend to contain much less of these elements. Lead, particularly, is likely to become a relatively scarce element over the next generation, but the prospect is not too bothersome because as the price increases it is expected that the uses of lead in paint, insecticides, and other non-reclaimable applications would cease because satisfactory substitutes already exist. In batteries, where lead appears to be essential, it is possible to retain the metal's corrosion-resisting properties by plating upon iron. Copper is now being partly displaced by aluminum in the electrical industry and in brass castings, and so long as copper remains more expensive these adaptations of technology will continue. Thus

the time can be easily foreseen when the geochemically common metals—iron, aluminum, and magnesium—will be predominant, and other metals will be used according to their availability. In the long term, failure of the essential industrial operations can not be visualized as resulting from the shortage of any of the major or minor metals.

The overwhelming importance of fresh water as compared to other bulk materials in the U.S. is typical of an extravagance not well afforded in many parts of the world. This level of consumption does not appear to be necessary, and engineers are now contriving systems for the re-use of water which could easily reduce this quantity to a half or less. Very likely only a tenth of this quantity would be absolutely needed if cultural changes were induced which made it more convenient to live with scarce water supplies. The other bulk materials, with the exception of phosphate rock, are available locally in almost every part of the world. Due to the enormous tonnages involved, the locations of bulk materials reserves do have an effect upon the location of centers of populations where consumption is intensified but very few countries, or even regions, are under a handicap with regard to the structural materials.

The availability of phosphate rock is a special problem. The United States possesses the bulk of the world's high-grade deposits, and therefore is expected to remain the major exporter. Phosphorus is an essential element presently being removed from the soil in larger quantities than it is being replaced, even in the United States, where phosphate consumption is heaviest.

Thus the world will be forced to depend upon phosphate reserves which are of constantly decreasing grade and which will therefore require increasing quantities of energy to release and make available to plants and animals. Review of the technology of phosphorus shows that it requires three tons of coal to produce a ton of available phosphorus using currently available deposits (30–40 per cent P_2O_5), but this is estimated to increase to 20–30 tons of coal per ton of phosphorus when rock containing only 5–10 per cent P_2O_5 is utilized. Thus the world's phosphorus problem is seen primarily as an energy problem where the energy costs may increase to an unprecedented level. Then it may become economical to salvage phosphorus from sewage wastes and perhaps even cemeteries and retain it in the cycles of human activity rather than permit it to be dispersed in marine sediments.

MINERALS CONSUMPTION AT A HIGH STANDARD OF LIVING

(approximate U.S. average per capita, 1948)

Source: Minerals Yearbook, U.S. Dept. of Interior

TABLE I
FUELS

Coal	8,000 lbs.
Petroleum	4,000
Natural Gas	1,400

TABLE II
MAJOR METALS

Pig iron	800 lbs.
Copper	34
Zinc	12
Aluminum	9
Lead	9
Manganese	8
Nickel	1.2

TABLE III
SOME MINOR METALS

Tin	0.9 lb.
Cobalt	0.8
Antimony	0.2
Molybdenum	0.17
Magnesium	0.12
Vanadium	0.07
Tungsten	0.06

TABLE IV
BULK MATERIALS

Fresh Water	300,000 lbs.
Sand and gravel	4,300
Stone (blocked and crushed)	3,000
Cements	500
Clays	420
Phosphate rocks	115

TABLE V
NON-METALLIC MATERIALS

Salt	220 lbs.
Gypsum	80
Lime	60
Sulfur	33
Soluble Sulfate and Carbonate	20
Potash (as K_2O)	15
Chromite	14
Titanium dioxide	4
Magnesia	3

THE ENERGY PROBLEM

As the minerals status is reviewed it becomes more and more apparent that the supply of metals and essential non-metals hinges upon the availability of energy. Yet the energy resources are being depleted most rapidly! As new resources are tapped, however, it is to be expected that marginal costs will increase; otherwise the resources would have been used earlier.

At present there are two potentialities which may provide power in the quantities required—nuclear fission and solar energy. We can imagine that one more, the reacting of light elements, may possibly be worked out. These resources have peculiar cost characteristics which will have an important bearing upon applied science and technology. Nuclear reactors, for example, are far more economical to operate at lower temperatures and pressures so that the cost of process steam in large quantities, for example, may remain virtually constant while the cost of electric power may increase by a factor of seven, according to latest published estimates by the U.S. Atomic Energy Commission. Much the same is true of the techniques for utilizing solar energy. Low-grade heat, such as may be used for home heating, distillation, etc., may remain fairly cheap, but when solar radiation is converted into electric power, coke, or liquid fuels, the expense is likely to be at least five–ten times the present costs.[2]

TABLE VI
CONSUMPTION OF REPRESENTATIVE MINERALS IN ASIA

Water	30,000 lbs.
Coal	250
Salt	13
Pig iron	5
Oil and gas	3
Copper	0.2

Unfortunately, the most common

[2] "Cost" is an elusive term here. The labor content will very likely not increase but capital investment, measured in physical quantities, could easily be multiplied by ten. Since the principal power costs are capital costs, the charges for electricity must be increased appropriately.

metals require a considerable amount of high-grade energy. The iron and steel industry now consume about two and one-half tons of coal per ton of metal, and the cost of this coal now amounts to about 25 per cent of the sale value. Thus, if the cost of coal were multiplied by ten, the cost of steel would be multiplied by three and one-fourth, assuming all other prices, and the technology would remain constant. The prices of aluminum and magnesium would be even more severely affected because of the quantities of electric power which are required. (Titanium, which has been heralded recently as a new major competitor for light metals and stainless steel, also requires tremendous quantities of high-grade energy for its reduction from the oxide.)

These price changes for the basic stuff from which machines are made will not stifle industry but they will put much greater emphasis upon economy of consumption. People will be forced to design their equipment with the least possible amount of these expensive materials and will be careful to work out systems for saving scrap and reclaiming the metal. Each time a metallic article is scrapped some energy is required to melt it down and put it back into the cycle of human use, but for iron, aluminum, and magnesium this is much less than required for reduction from the ore.

Thus the iron age will not pass out of the picture with the fossil fuels. Even if we were to use photosynthesis for hydrogen production (or for reduced carbon) rather than coke, iron would remain the most economical and the most adaptable metal available. Aluminum, copper, magnesium, chromium, nickel, vanadium, and titanium would appear to fill the role of secondary, higher-cost alternatives used for special purposes.

EXPLOITING LOW-GRADE DEPOSITS

The procedure for exploiting low-grade deposits on the massive scale required, if several billions of people are to be maintained at a reasonable standard of living, will take on quite a different appearance from the mining and smelting of ores today. Single developments will dwarf the Mesabi in size of operations, and the methods of handling bulk materials will have to be refined to the *n*th degree. In each case it is very likely that a series of principle products and by-products will come out of a highly interlocked and integrated refining operation.

We know that finely powdered rock is best conveyed, and the minerals in it are better differentiated, when in an aqueous medium. However, there are few places in the world where suitable rock is accompanied by sufficient quantities of fresh water to accomodate the large-scale facilities needed, and accumulation of wastes would be so large as to overwhelm the operations, unless the people living farther down the river were willing to tolerate its contamination.

The most logical site would be at the oceanside where short pipelines could deliver troublesome wastes into ocean currents, to be diluted rapidly.

Ocean water might well be brought into the processes because of its economy, and its soluble salts could undoubtedly be processed on the spot to acids, alkalies, and other bulk chemicals needed for processing and purifying the ores to the point where reduction to the metal was feasible.

There are many formations of low-grade mineralized rocks of suitable extent where this integrated development might occur—the kolm shales adioining the Baltic Sea are one important example. One can foresee a gradual approach toward exploitation of igneous rocks which do not differ importantly from the average composition of the crust of the earth. It is interesting then to describe the limiting case and assume that a technology has been developed which separates the respective metals and non-metals with approximately the same efficiency, i.e., if say, 60 per cent of the iron can be processed into suitable iron ore, then 60 per cent of the tungsten oxide, and 60 per cent of the silver can also be extracted, the remainder being lost in tailings.

When looking carefully at the prospective economic value of the various constituents in average igneous rock one sees that some of the most common elements are valueless because they could be obtained in virtually inexhaustible quantities in concentrated deposits elsewhere. Silica, calcium, potassium, sodium, and aluminum compounds all fall into this category. Iron ore is the best excuse among the common elements for large volume handling. If we assume that the world will want at that time an additional 10^8 tons of iron and steel products annually (approximately the present world production level) then one would find associated with it the quantities of metals and other mineral products listed in Table VI. The conjectures as to value are based largely upon present prices and foreseeable developments. They are only included so as to give a rough weighting of the economic importance of a constituent and beyond that are not at all defensible.

An important item to be noted here is that 25,000 tons of thorium and uranium are released. This should provide enough energy to operate the whole process from the milling and pulverizing stage to the reduction to metal, including all the intermediate physical and chemical processing, and still leave a considerable surplus. One can visualize the employment of largely automatic equipment, similar to that which operates in a modern oil refinery, where each stage functions routinely.

UNFINISHED BUSINESS

The units which approach this ultimate limit would reach a complexity comprehended only by the best of the process engineers. It is the kind of project which would stimulate their imagination, and some might even be impelled to pull out their charts, handbooks, and slide rules to work out a tentative process design. The impulse, however, leads only to frustration. Not only is the engineering experience insufficient, but much of the science is also lacking.

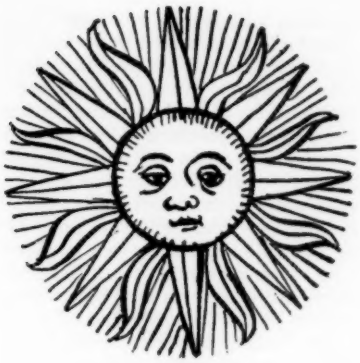
No one knows, for instance, the microscopic distribution of the elements in ordinary rock. Fortunately, with experimental nuclear reactors and isotopic dilution techniques, it is possible to start to accumulate information of this sort. Then too, there is little known about the rates at which the useful constituents can be extracted from their crystalline matrices and put into aqueous solution. Relationships between particles of rock and solutions of the new synthetic detergents and foaming agents must be made more understandable and predictable. More unsolved problems crop up the more one inquires into the details. They appear to have reasonable answers but one cannot consider investing the necessary tens of billions of dollars until the performance of the process can be predicted.

The outlook then for minerals sufficient to cover the industrial requirements of the other two billions of people whose level of living is still inadequate is quite favorable.

There does not appear to be any challenging new line of research which is lacking attention in these directions, since general progress along a broad scientific and technological front should suffice to take care of the unsolved problems.

FUTURE USES OF SOLAR ENERGY

MARIA TELKES



Someone once calculated that the enormous power involved within the huge "atomic energy" reactors at Hanford, Washington, does not surpass the solar energy which every day in the form of sunlight falls unused upon the roofs of the Hanford buildings. Dr. Maria Telkes, of the Department of Metallurgy at Massachusetts Institute of Technology, an enthusiast of solar energy possibilities, wrote this article in one of the first homes ever heated by solar energy summer and winter—Dr. Telkes' own home of her own design.

SOLAR energy may be evaluated in terms of atomic energy, by comparing the theoretical energy equivalent of the fissionable material with that of solar energy received on the earth's surface. The heating value of 1,500 tons of coal is equivalent to one pound of U-235[1] representing 3×10^{10}Btu.[2] In the temperate zone on a clear day 2,000 Btu is received from the sun by one square foot horizontal surface during the summer, or 5.5×10^{10}Btu per square mile. One pound of U-235 is therefore nearly equal to the amount of solar energy received on a half square mile on a clear summer day. The above comparison does not take into account the efficiency of converting either energy form into useful energy.

Solar energy has been evaluated recently in terms of fuel values, technical uses, and human needs by Daniels,[3] Ayres,[4] Daniels, Hubbert, and Wigner.[5] Solar energy received by the land area of the United States is 2,000 times greater than the total fuel consumption, without comparing the efficiency of conversion of either energy form.

THE AMOUNT OF SUNSHINE

The amount and distribution of solar energy in the United States are well known. The Weather Bureau records contain adequate statistics.[6] Solar energy can be expressed in various units:

Energy units per (square foot.hour)	One hour of clear sunshine around noon, at optimum incidence near sea level
Btu	330
Kg.cal	83
Watt-hour	97
Foot-pounds	255,000
HP-hours	0.13

One hour of clear sunshine on one square foot, as specified above, is comparable to:
Wind—27 miles per hour on one sq. ft. for an hour;
Water falling 100 feet—300 gallons;
Manufactured gas—½ cubic foot;
Coal—0.03 pounds.

According to the Weather Bureau statistics, one square foot of horizontal surface receives in an average year the amounts of solar energy expressed in the following table in equivalents of pounds of coal and cost of the latter (assuming that one pound of coal produces 10,000 Btu, and one ton costs $10.00).

Location	Solar Energy Btu / square ft. year	Coal lbs.	Cost of coal dollars
Honolulu, Puerto Rico	800,000	80	$0.40
S. California, New Mexico, Arizona	550,000–700,000	55–70	0.27–0.35
Washington	450,000	45	0.225
New York	400,000	40	0.20

PRINCIPLES OF SOLAR ENERGY CONVERSION

The use of solar energy depends upon its conversion into useful energy forms. The theoretical principles and limitations of such energy conversions are well known.

The amount of solar energy that can be collected depends upon the effective area of the collector, and the possibility of placing it so as to receive the maximum amount of sunshine during the major part of the time cycle of its use. The design of the solar energy collector is not an easy task, because account must be taken of the diurnal and seasonal changes in the position of the sun in the sky, and its construction costs are limited by economic considerations.

The efficiency of solar energy collection, that is, the percentage of the

[1] L. A. Ohlinger, "Engineering Aspects of Nuclear Reactors," *Nucleonics*, VI (March 1950), 46–57. "If all the readily available supply of uranium in the earth's crust were converted to energy for man's use, it would only last about a thousand hours. Even the readily available uranium in the United States could only supply all our power needs for a matter of months.

[2] Btu (British thermal unit) is the amount of energy required to heat one pound of water by one degree Fahrenheit.

[3] F. Daniels, "Solar Energy," *Science*, CIX (1949), 51–57.

[4] E. Ayres, "Major Sources of Energy," American Petroleum Institute, Division of Refining, XXIX (1948), 109–42.

[5] F. Daniels, M. K. Hubbert, E. P. Wigner, "Solar and Nuclear Energy," *Physics Today* (April 1949), 19–22.

[6] I. F. Hand, "Weekly Mean Values of Daily Total Solar and Sky Radiation," U.S. Weather Bureau Technical Paper No. 11 (1949), 1–18; I. F. Hand, "Isolation on Clear Days," *Heating and Ventilation*, XLVII (January 1950), 92–94; S. Fritz, "Solar Radiation During Cloudless Days," *Heating and Ventilation*, XLVI (January 1949), 69–74, and XLVI (July 1949), 72–75; U.S. Weather Bureau, Climatological Data, Monthly.

incident solar energy convertible into useful energy is limited by certain unavoidable losses. Devices in which solar energy is converted into *heat*, and utilized as such without further conversion to mechanical or electrical energy, can attain considerable efficiency. Examples of this type are the solar water heaters used in semi-tropical regions.[7] Their efficiency may be as high as 50 to 80 per cent on clear days, depending upon the amount of sunshine, the temperature of the water, and the skill of the designer.

Solar heating of houses, recently carried out around Boston[8] and elsewhere indicated that winter sunshine can be usefully collected with an efficiency of 35 to 40 per cent. The collected sunshine may be stored in water, or as the heat of fusion of low-cost chemical compounds. On clear winter days, 50 to 60 per cent of the incident solar energy can be collected. It should be remembered that the average efficiency of the coal furnace used for house heating is around 50 per cent and the first solar heated houses nearly approach this efficiency.

For thousands of years the human races shivered in the winter (many still do) using wood-burning fireplaces or stoves, with an efficiency of 5 to 10 per cent. Considerable research and development were needed to produce the highly efficient furnaces of today. Further research and development work on the solar heating of houses should similarly improve their efficiency and diminish the costs.

It is possible to combine solar house heating with summer cooling to provide additional comfort. For this purpose, solar heating may be combined with the Heat Pump.[9]

Another solar heat-transfer application of high efficiency is the *solar distiller*. Tropical arid islands could receive sufficient potable water, by distilling sea water, using the overabundant sunshine for this purpose.[10] The efficiency of this process is around 60 to 70 per cent in the tropics. Development work on solar stills for life rafts led to their use during the last war. Further development work is needed, before large-scale solar sea water distillation will be economically feasible. The by-product—sea salt—also may be valuable. Around 700,000 tons of "solar salt" are produced yearly by open evaporators, mostly in the region of San Francisco.[11] The economy of arid tropical or sub-tropical regions may be improved considerably by large-scale solar distillation, combined with by-product use.

"Solar engines," in which solar energy, collected as heat, is then used to produce electrical or mechanical energy, are limited in efficiency by the second law of thermodynamics, in the same way as fuel-operated engines. This law determines that the efficiency of a heat engine is the higher the larger the temperature difference available to operate the engine. The high temperature level, needed for efficient operation can be attained, in the case of solar engines, only by concentrating the radiation falling upon a comparatively large area, on a relatively small heat transfer body. Means of concentration (lenses, parabolic reflectors) must be accurately focused and their construction is rather intricate and expensive. The largest *solar steam engine*, built by Shuman in Egypt, had an efficiency less than 5 per cent.[12] The *solar steam turbine* of Dr. C. G. Abbot had a calculated efficiency of 15 per cent.[13] The efficiency is not mentioned in the meager reports available on the recent experiments at the only existing Solar Power Institute located in Tashkent, in Soviet Central Asia.

With improved materials for *thermoelectric generators*,[14] an efficiency of about 5 per cent appears feasible in the conversion of solar energy into electrical energy by the heating of one junction of a thermoelectric couple. At the same time, a much higher proportion of absorbed solar energy can be recovered as heat at a moderate temperature level, and utilized for house heating purposes.

An entirely different type of solar energy converters can be based on photovoltaic, or photogalvanic cells, in which light energy is transferred into electrical energy without preliminary conversion into heat, and which are therefore not limited by the second law of thermodynamics. Although considerable research and development work has been carried out with *photoelectric cells* for signaling and communication purposes, not much progress has been achieved in increasing their efficiency as energy converters. Even if inherent difficulties could be eliminated, the efficiency of the presently known types of these cells is probably not much above 0.1 per cent.[15]

Thus far the greatest research efforts in the utilization of solar energy were in the field of *photochemistry*, notably in photosynthesis. Agricultural research is largely the study of applied *photosynthesis*, with the purpose of increasing crop yields. The forests of the temperate zone convert solar energy

[7] F. A. Brooks, "Solar Energy and Its Use for Heating Water in California," California Sgr. Experimental Station Bulletin No. 602, November 1936, 64 pages; H. M. Hawkins, "Solar Water Heating in Florida," Florida Engineering Experimental Station Bulletin No. 18, September 1947.

[8] H. C. Hottel and B. B. Woertz, "The Performance of Flat-Plate Solar-Heat Collectors," *Trans. A.S.M.E.*, LXIV (February 1942), 91–104; M. Telkes, "Solar House Heating—A Problem of Heat Storage," *Heating and Ventilation*, XLIV (May 1947), 68–75; M. Telkes, "A Review of Solar House Heating," *Heating and Ventilation*, XLVI (September 1949), 68–75; M. Telkes, "Storing Solar Heat in Chemicals," *Heating and Ventilation*, XLVI (November 1949), 79–86; A. G. H. Dietz and E. L. Czapek, "Solar Heating of Houses by Vertical South Wall Storage Panels," *Heating, Piping* (March 1950), 118–26.

[9] Energy of any form (such as heat or electricity) can be used to "pump" heat from a cooler to a warmer place. In a kitchen refrigerator, heat is "pumped" from the inside of the refrigerator into the room; a heat pump can be used to pump heat inside of the house to the outside in summer, and in the opposite direction in winter.

E. R. Ambrose, "Heat-pump Installations for Residential Use," *Mechanical Engineering* (February 1951), 115–20.

[10] M. Telkes, "Solar Distillation," *Industrial and Engineering Chemistry*, Publication pending.

[11] E. F. Armstrong and L. M. Miall, *Raw Materials from the Sea*. Chemical Publishing Company, 1946.

[12] A. S. E. Ackerman, "The Utilization of Solar Energy," *Journal of the Royal Society of Arts*, LXIII (1914), 81–165. Reprinted in Smithsonian Report, 1915.

[13] C. G. Abbot, *The Sun*, New York: Appleton, 1929; C. G. Abbot, *The Sun and the Welfare of Man*, Smithsonian Scientific Series No. 2, 1944, "Harnessing the Sun," pp. 206–63; C. G. Abbot, *Utilizing Heat from the Sun*, Smithsonian Publication No. 3530, March 1939; C. G. Abbot, Solar Radiation as a Source of Power, Smithsonian Publication No. 3742, 1944.

[14] M. Telkes, "The Efficiency of Thermoelectric Generators," *Journal of Applied Physics*, XVIII (1947), 1116–27; B. D. Cullity, "Thermoelectric Properties of Bi-Se Alloys," A.I.M.E. Technical Publication No. 2313, January 1948; B. D. Cullity, M. Telkes, and J. T. Norton, "Antimony-Selenium Alloys," *Trans. A.I.M.E.*, CLXXXVIII (January 1950), 47–52; M. Telkes, "Thermoelectric Power and Resistivity of Minerals," *American Mineralogist*, XXXV (1950), 536–55.

[15] V. K. Sworykin and E. G. Ramberg, *Photoelectricity and Its Application*, New York: John Wiley, 1949.

into combustible wood at an efficiency not greater than 0.1 per cent.[16] A high corn yield of 100 bushels per acre and the additional fuel value of all by-products of growth, result in an efficiency of 1.6 per cent during the growing season. The primary role of photosynthesis is to produce food. A "fuel-growing" process has been suggested, based on growing a high yield crop, drying and bricketting it and finally burning it for heating purposes. This process, involving transportation costs and labor, probably cannot produce, over a year, a yield greater than 0.4 per cent, which compares unfavorably with the 35 to 40 per cent efficiency obtainable with direct solar house heating.

FUTURE OUTLOOK

There is increasing interest in the sun, as an untapped and potentially unlimited natural resource, for heat and for power. Conservative engineers treat this subject with near derision, pointing to the fuel reserves in oil, natural gas, and coal. On the basis of use at the present rate and of use at a progressively greater rate, the estimated fuel reserves of the United States should last for 100 to 1,000 years.

A goal definitely more remote than a life-span is of secondary interest to most people, in particular to many engineers, who prefer to engage in the pursuit of tangible results, achievable within a short time. However, technological changes that may occur during a century may be vividly imagined by comparing the technology of 1851 with that of today. The past fifty years alone saw the automobile and the airplane emerging from the "impossible" category. The horse and buggy appeared as the best solution of the problem of transportation and agriculture fifty years ago. The rapid development of the automobile did more than relegate the horse to the race track; it created entirely new problems and techniques, such as the assembly line, highway construction and gasoline stations, Suburbia, Motels, and drive-in movies.

The direct utilization of solar energy at the present time may be compared to the automobile in its infancy. Like those who preferred the horse, there are those who insist that with domestic fuel reserves assured for another 100, possibly 1,000 years, there is no need to indulge in a search for substitutes. Even if the estimated domestic resources of petroleum and natural gas could last for only ten or twenty years, there are the foreign sources, or other already well-known processes, such as gasification of coal—so they say.

Finally, it is becoming commonplace to look to atomic energy as the future answer to any fuel or power shortage, even if estimates indicate that the readily available uranium deposits, if fully utilized, could cover the heat and power requirements of man for only 40 days.[17]

Finally, we have to think not only of the United States, but of the vast, densely populated areas of the world which have no adequate resources of coal or oil.

With the exception of the polar regions solar energy is available everywhere; it does not need transportation facilities and cannot be cut off by sudden emergencies created by man. Solar energy cannot produce soot, fire hazards, and mining accidents. It is the cleanest and healthiest fuel.

Solar energy utilization requires ingenuity in overcoming the scientific, technical, and economic problems. It calls on almost all branches of physics and chemistry and requires the teamwork of specialists in many fields.

The total research and development expenditures made thus far in solar energy utilization are infinitesimal when compared with the expenditures made in the development of other natural resources. Sunlight will be used as a source of energy sooner or later anyway. Why wait?

[16] Ohlinger, *op. cit.*

[17] Daniels, *op. cit.*

The Congressman and The Bomb

Report of experiments conducted at Eniwetok. From a newspaper account by F. Edward Hebert, Congressman and former newspaper editor.

ENIWETOK, 1951—Except for the knowledge of what was to take place in a few minutes the scene could well have been any exclusive beach club on any exclusive beach from France's Riviera to California's Palm Springs.

We were told that a 10 second warning would be given before the explosion.

All around was the repeated warning:

"Be sure your glasses are adjusted properly."

Then came those last ten seconds which I shall never forget. The ten seconds before the explosion when anything could happen if something went wrong.

The observer next to me remarked in a hollow voice: "Well, we will know if it works in a few seconds. How do you feel? Do you think it will go off?"

"Seven seconds."

I wondered what the others were thinking. What emotions were they experiencing? It was old stuff to many of them. It was new to all of us because this was to be the greatest and mightiest explosion ever set off or witnessed by man.

"Six seconds."

I gritted my teeth and the panorama of the horrors of Hiroshima and what I had seen there and the ruins among which I had walked became vivid to me once again.

"Three seconds."

I was beyond the stage of apprehension. I was scared and I was afraid that we might be the real guinea pigs if something went wrong.

"Two seconds."

I couldn't stop repeating the question to myself. "What am I doing here? It's to late to turn back now, but what am I doing here?"

"One second."

Then it came.

The sky was all lighted.

There was a gigantic ball of fire on the horizon.

Simultaneously there was a gust of heat across my face.

The fire and the heat seemed to come at the same time.

There was no sound.

It was just the sense of sight and touch—no hearing.

I was choked with emotion. I wasn't shaking but I was unsteady. I didn't cry but I know I could have. What a peculiar and funny effect! Perhaps the knowledge that nothing had gone wrong caused the sensation, perhaps the knowledge that we were still there.

I looked in the sky as the now familiar pattern of the gigantic mushroom of Bikini formed and soared heavenward.

ECA: PLANS AND PROSPECTS

PAUL R. PORTER

Paul R. Porter is Assistant Administrator for Program in the Economic Cooperation Administration. In the following article he describes the already encouraging results of America's economic aid to the poorer nations of the free world and discusses what America can do to continue the strengthening of these ravaged countries.

AMERICA has been thrust, whether we like it or not, into the position of world leadership. It has moved into a position of power unique, I believe, in history. But America's rise to leadership coincides with a profound restlessness in the minds and emotions of people throughout the world. This restlessness comes from a deep discontent with poverty. In Latin America, Europe, Asia, and Africa, many millions of people are determined to achieve a higher standard of living—not eventually but now. Unless we can help them rise from poverty—and for many, squalor is a more precise word—they will turn to the Soviet Union for leadership.

If that happens, America, with its vast economic power, its high standards of living, and its gigantic industrial capacity, would find itself on a lonely peak of power, surrounded by envy, hostility, and insecurity. As misery elsewhere increases, danger to us would mount; mobilization and civilian sacrifices would have to rise to unbearable proportions.

Our job then, is to use our position of economic power and leadership to bring about those economic conditions within the free world which can assure peace, mutual friendship, and security. We must use economic development as an instrument of our foreign policy, an instrument for waging peace.

In one of the major areas of the world, Western Europe, our policy of helping others to help themselves has already been a remarkable success.

When the last great war ended the economic power of Western Europe was virtually destroyed. Factories lay in ruins; railroads, harbors and waterways, and almost all essential transportation services were wrecked; mines and fields were out of production; inflation was menacing already dangerously low standards of living.

If America, which emerged economically strong and powerful from the war, had let Europe fend for itself in those dark days, I think there is little question but that today many of the countries of Europe would have been lost to the community of free nations.

In the Marshall Plan we accepted the challenge to our responsibility and moral leadership.

Operating through the ECA, America sent to Europe modern industrial machinery and funds to rebuild harbors, railroads, and bombed-out plants. It helped restore and build power dams, bridges, and mines. It sent ploughs, tractors, and seeds to Europe's farmers. Under the leadership of Paul Hoffman and William Foster, it placed the talents, time, and initiative of some of America's most able businessmen, agriculturists, and labor leaders at Europe's disposal.

The result has been what is rightly called "the most courageous comeback in history." In three years, instead of the expected four, European rehabilitation is now virtually complete, an unprecedented ascent from rubble to recovery.

Let me give you a few brief statistics that show how great that recovery has been. Free Europe's total industrial production is now 40 per cent above 1938; eliminating Germany, it is 50 per cent above 1938. Agricultural production is up 9 per cent; power production 100 per cent; steel production 25 per cent. Most hopeful of all, perhaps, has been the formation of the Organization of European Economic Cooperation, a unit through which the several European nations for the first time in history can work together on mutual economic problems. And this incredible job was done not by the domination or political control of Europe by America, but in a spirit of democratic fraternity and partnership, a mutual respect for each others' sovereignty, dignity, and political choice.

The most significant part of the recovery has been intangible—the strengthening of Europe's will and morale against the threat of Soviet seizure. Everywhere the tide of communism which three years ago so clearly threatened many of the free countries of Europe has been turned back.

The question today is—shall America continue to exert its power and leadership for economic betterment? Shall we continue the concept of the Marshall Plan, of economic partnership, not only with Europe but with other countries of the free world which in their different ways, as surely need our help as did Europe three years ago? Will we throw our economic power—and our moral and spiritual force—into the world-wide struggle for greater economic development and human freedom?

Let us take first the question of Europe: At this moment, as partners with America in the North Atlantic Treaty, 275 million Europeans are standing with us in defense of our common freedoms. We must help them increase their production of arms, and increase their industrial power to maintain strong defenses.

ECONOMIC REASONS FOR STRONG DEFENSES IN WEST EUROPE

Aside from the purely strategic reasons for enabling Europe to develop strong defenses—there are also some good economic reasons. If Europe produces its own arms, it accomplishes a threefold purpose: first, weapons are produced right on the spot where they must be ready for use; second, they will be produced by European plants and labor—thus relieving America's productive capacity and our civilian

Address given at Conference on World Affairs, Boulder, Colorado, on April 12, 1951.

economy of a very heavy extra burden; third, the cost to ourselves of Europe's rearmament will be greatly lessened. It has been carefully estimated that for every twenty-five cents we put into European rearmament, the Europeans will put in seventy-five cents of their resources.

In short then, by helping Europe to rearm, we gain weapons at an acute point of Soviet pressure; and our contribution is twenty-five cents of each dollar value instead of the whole.

But, in addition to helping Europe rearm, there is a further task which must be our concern. Even with the solid groundwork built by the Marshall Plan, the Marshall Plan countries are still not strong enough to maintain—by themselves alone—the kind of defense program that the Soviet menace requires—without seriously impairing the living standards they have so recently restored. For Europe to provide the necessary total of armaments that security demands, would mean almost literally for them a choice between, not guns and butter—but, guns and bread. For let us remember that their living standards are at best far, far below our own. Any serious impairment of these standards would change the psychological climate of hopefulness and confidence, and of the will to resist Soviet threats, into pessimism, doubt, and neutralism—or even worse. It would certainly generate the kind of social and political unrest which might leave Western Europe even more vulnerable to attack from within than she is now to aggression from without.

We do not believe that the choice of Europe must be between guns and bread. We are convinced that the Marshall Plan countries can, within a resonable number of years, increase their total output of goods and services by an additional one hundred billion dollars annually. And that is almost double their present rate of one hundred fifty billion dollars. If they achieve anything like this goal, they could carry a defense program of forty to fifty billion dollars annually, if necessary—and *at the same time raise their standards of living by 50 per cent.* And, what is most important, both to American taxpayers and to the Western Europeans themselves, today's Marshall Plan countries could then become completely independent of outside economic assistance.

As we see it, America's particular part of the job will be to show them that the goal of increasing their output by one hundred billion dollars is something that can and must be done. This job will not be an expensive one in terms of American dollars. But it will be a heavy one in terms of American planning and ingenuity, of technical aid, and of the careful close and friendly cooperation between labor and business and agriculture on both sides of the Atlantic.

HOW AMERICA CAN HELP

First of all, we must expand our present technical assistance program, which we have developed under the Marshall Plan, and convey to Europe's plant managers, businessmen, and workers the technical information necessary for raising production.

Second, we must urge that the savings which result from increased production be passed on in the form of lower prices and higher wages—and not simply accrue as larger profits for the benefit of the few.

Third, with the help of these lower prices and higher wages we must encourage Europe to develop, through modern merchandising and distribution methods, mass markets for its goods.

Fourth, we must help replace the all too numerous self-strangulating practices by which Europe today restricts output, limits markets, and pegs prices at a high level. Part and parcel with this, we must encourage sound financial policies on the part of business and government.

Fifth and last, we must not only help Europe to install the most modern productive equipment, but teach European plant managers and workers how to use it—and why it must be used if productivity and living standards are to be raised.

These then are some of the big jobs remaining for us in Europe—I believe these are the jobs we must do, if we are to count on the people of Europe as our military and spiritual allies against communist aggression.

What about the other nations of the free world? Asia, Africa, the Middle East, Latin America—each of these regions stands today in sharp, dramatic, and self-confessed need of economic development and expansion. In spite of their great differences, they have several important similarities. They are the main suppliers to the United States of strategic raw materials—of tin, copper, rubber, cobalt, manganese—and scores of others without which American production and American security cannot be maintained. The majority of their peoples labor under poverty, illiteracy, disease, and hunger. Further, all their peoples have growing and imperative aspirations toward economic betterment and greater human freedom—aspirations which if unfulfilled can lead to an acute social and political unrest which the Soviet power is only too ready to exploit. Finally, all these areas are strategically essential to America as a military and economic shield against Soviet aggression. In short, all of them present some of the gravest economic problems of the free world community. What, then, must America's role be toward them?

THE PROBLEM OF SOUTHEAST ASIA

I would like to discuss with you one of these regions which is today of particular strategic importance—Southeast Asia. This is an area which I feel will demand from our government, and from the people of the United States, the most immediate, pressing, and critical decisions.

I believe there is little question that unless the United States and the West take effective action to help the countries of Southeast Asia build the essential conditions of freedom, we will see them taken over by communism, organized and exploited for the benefit of the Soviet Union, closed to trade, closed to Western ties and culture, closed to the growth of freedom based on responsibility. This is probably true of all of Asia. I need hardly say that the loss to the Communists of all or any part of Southeast Asia would be an incalculable blow to the security and resources of the free world.

Let me explain in some detail just why such a potentially disastrous situation exists.

First, virtually all the countries in this area have only recently thrown off the centuries-old domination of strong colonial powers. Their governments are new and untried; they are surviving today largely on nationalist fervor and enthusiasm for independence. They are making a tremendous eager effort toward progress against most serious handicaps.

Most of them were severely ravaged by the recent war and Japanese occupation. Some are still beset by internal struggle and guerrilla warfare. In others even such basic government functions as tax collection have broken down. Health, education, and transportation services, even where these had been established under colonial rule, are now either non-existent or at best rudimentary.

There is no adequate reservoir of trained civil servants, no competent

bureaucracy to handle reconstruction programs. And there is only a tiny core of educated and trained persons outside the civil service in a professional or leadership group.

Although the countries are, generally speaking, rich in natural resources—in oil, tin, rubber, and rice; from the standpoint of the West, there is no balanced economy, and to all practical purposes, very little industry.

Added to this there has taken place, along with political independence, what has been called a "revolution of rising expectations" among the peoples themselves. Today the people of Asia expect more and not less—more health and social services, more economic advantages, benefits, and opportunities. They have been increasingly influenced not only by Western ideals of political independence and self-determination, but Western ideas of progress, of the dignity of man, and especially the Western demonstration that modern science and technology can be applied to fulfill human needs. They are beginning to exert and will increasingly exert pressure upon their governments to provide these services, these tangible benefits of progress.

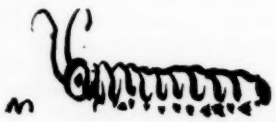
The plain fact is, however, that these governments cannot, without our help, provide the services demanded by their people—or rather, cannot provide them quickly enough to meet the increasing communist pressures.

For there is scarcely a country in Southeast Asia that is not today threatened by internal communist subversion, in many cases by direct Soviet or Chinese pressures, operating partly through the large Chinese population living there, and partly through the close geographical impact of Communist China itself. It is already clear that Southeast Asia is an area in which the Soviet power is prepared to undertake outright aggression. Moreover, from their experience in China, Communists have become adept at appeals to the hopes and aspirations of the Asian peoples. To the landless and debt-ridden peasant, communism promises land and abolition of debt; it has worked out cynical appeals for exploitation of other awakening human needs.

The security of free Asia depends fundamentally, therefore, on how effectively America and the West can help the governments of free Asia meet the elementary needs and expectations of their people.

This job will not require much capital—for Asia's ability to absorb capital is limited. Rather, what is needed in the years immediately ahead is assistance primarily of a technical and advisory nature to help the local governments administer their own resources and solve their own problems.

One of the most important problems is to work with the governments to increase agricultural production. We must help them introduce modern farm machinery, not necessarily tractors, but steel ploughs and hoes to replace broken sticks they use now. We must help them develop better strains of seed, of livestock, better methods of food distribution. And we must encourage them to provide incentives to peasants in the form of reduced debts, to revise oppressive farm tenancy contracts, and to develop facilities for cheap farm credit.



Next, we must help the governments establish public health systems, immunization and treatment against the many preventable diseases which now needlessly ravage the people, and modern medical training facilities.

We must help the governments improve their public administration techniques, and train a cadre of competent civil servants.

We must help them develop their industry and resources, build better roads, ports, and harbors, and provide modern distribution and trade management.

As you all know, I am sure, ECA has already undertaken to render exactly this type of assistance. The capital involved is extremely small—only fifty-nine million dollars within the current fiscal year for the whole area of Southeast Asia—plus about the same amount again in Formosa. The imperative necessity now is to extend this inexpensive aid, applying it in the most vigorous and dynamic manner, with the utmost effect.

For let us not forget, that though the means suggested here and already being used by ECA, are technical and economic, they are precisely the means by which we can accomplish our basic purpose: That purpose is to strengthen the ability of the governments to give their people direct tangible benefits and sound hope for even greater future betterment. It is thus—and I think only thus—that we will bring about security in Southeast Asia, and a full partnership of its peoples with the other peoples of the free world.

I regret there is not space to discuss in detail ECA's work in the region of Africa, that is, in the dependent territories, where the whole complex of problems is entirely different from that of Southeast Asia. Our work in Africa has been largely in developing new resources for raw materials—for industrial diamonds, copper, lead, and zinc on French Equatorial Africa, for cobalt and copper from North and South Rhodesia, for iron ore in French Guinea, for kyanite in Kenya, and in building roads, ports, and other transportation facilities to ship these critical materials out. Obviously, with the tremendous and increasing demand for raw materials, we must continue with this type of development program.

I regret, too, that I have not the time here to tell something of the job that is being done, and being projected under Point 4—the President's bold new program to aid underdeveloped areas. Already an excellent start has been made under this program, particularly in Latin America, closely paralleling what ECA has been doing in Southeast Asia.

I think it must be clear, however, from even this brief discussion, how tremendously important the whole question of economic development, economic aid, and aggressive economic policy is to the security and stability of our free world. And I think what must be equally clear is the very heavy responsibility that America, as leader of the free world, bears in carrying out such a policy.

For it is very obvious today, as America becomes the world's most powerful nation, that we can choose two separate paths. One is to withdraw into ourselves, bristling with military power, content merely to enforce the peace. The other is to use our power to help the nations of the free world build an ascending scale of freedoms, of economic opportunity, and human betterment for their peoples that will bind us all in growing ties of friendship and strength against communist subversion.

So far, we have chosen the right road. I am confident that the American people—if they are intelligently informed—will continue to choose the right road.

Let us hope that we do. For at the end of this road may lie peace for mankind.

TECHNICAL PROGRAMS IN UNDERDEVELOPED AREAS

As a background to discussion elsewhere in this issue of the potentialities of research and technology's future contributions to world development, the Bulletin here reviews some of the technical aid programs now actually at work. The facts and conclusions are drawn largely from official government reports. They are meant only to give an idea of the general size of the operations, without judgment on controversial aspects.

AMERICANS are familiar with the aims of the Economic Cooperation Administration (ECA), which administers the Marshall Plan, and the general aims of the Point Four program, but not many know very much about "The Colombo Plan" just begun among nations in South and Southeast Asia; nor can Americans readily understand how important for some countries have been international agencies such as UNRRA, UNESCO, and UN groups working in food, health, and other technical service and education organizations.

Even a cursory survey of the programs now being started in "underdeveloped" countries of the world indicates the implications for constructive action are of a depth and breadth worthy of comparison with the destructive trends of the cold war as indicated in the daily headlines. Such a survey also shows that scientists' and technicians' dreams of rational cooperative solutions to health and resources problems may still be far from reality, but the start which has been made is not negligible. By all previous standards the programs under way are rather large—in fact, huge.

If even an uneasy peace can be maintained for a generation, the achievements being planned will write an impressive chapter in the history of science in the service of mankind.

"PARTNERS IN PROGRESS"

United States technical and material aid to underdeveloped countries is still not fully unified, and the administrative questions of how it should be organized are now the subject of political controversy.

The "bold new program," nicknamed "Point Four," remains under the State Department, but the Economic Cooperation Administration is a separate agency, and other agencies enter the general field, occupation authorities sometimes operate on their own, and private investors and foundations maintain other programs.

In November 1950, the President appointed a citizen's committee, headed by Nelson A. Rockefeller, to study the whole field and make recommendations. This "International Development Advisory Board" made its report this spring, in a book called *Partners in Progress*, which has become known more familiarly as "The Rockefeller Report."

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The Advisory Board's recommendations were:

1. That there be speedy centralization and unification of major foreign economic activities of the U.S. government into one over-all agency, an Overseas Economic Administration, headed by a single administrator reporting directly to the President.

2. That, in order to facilitate close working relations with the United Nations, the New Overseas Economic Administrator have an Assistant Administrator charged with working with United Nations and other international agencies, and with voluntary groups.

It further recommended that another Assistant Administrator should be appointed to work with private enterprise, and that an International Finance Corporation should be formed to work with private enterprise abroad —as an affiliate of the International Bank.

For the major objectives of the central agency the Advisory Board recommended:

A. Cooperation with the underdeveloped countries in a vigorous food production drive which would attack hunger by increasing food production by at least 25 per cent.

B. The increase by about 50 per cent of the production of materials essential to defense.

The Advisory Board stated:

"The 1,075,000,000 inhabitants of the so-called underdeveloped areas outnumber the populations of either the highly industrialized nations or the area controlled by Soviet imperialism.

"Under Soviet control now live 750,000,000 people. . . .

"The other 500,000,000 live in the free, relatively highly industrialized nations.

"We peoples who are still free face two main threats. One is military aggression and subversion. The other is hunger, poverty, disease, and illiteracy. . . .

"The Advisory Board felt an added responsibility to examine the proper place of international development in relation to defense. . . . The Advisory Board feels that strengthening the economies of the underdeveloped regions and an improvement in their living levels are a vital part of our own defense mobilization."

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The size of the job was outlined by the Board as follows:

"To many people, the task of helping a billion people better their lot may seem a hopeless one. But how big is the job to be done in economic terms? According to United Nations estimates, the total annual income for the billion inhabitants of these areas would run about 80 billion dollars. The current United States' national income alone is well over 250 billion dollars, while that of the countries of Western Europe totals between 140 and 150 billion dollars. In 1949, the per capita incomes were $80 for the underdeveloped areas, $473 for Western Europe, and $1,453 for the United States.

"Taken alone, the economy of the United States has more than three times the productive output of all the economies of the underdeveloped areas together. Combined, the economies of Western Europe and the United States have five times the economic weight of the underdeveloped regions. It is in these terms that the job should be measured, not in population numbers but in economic output.

"The prevailing economic pattern of these regions could be revolutionized through a consistent investment flow from the Western industrialized world of several billion dollars a year, if combined with local capital and channelled into genuinely productive enterprise.

"Nor is this a task with which the United States is left to deal alone. Western Europe's dependence upon the underdeveloped areas, and their dependence upon Western Europe, is even greater than our own. The Board believes that the European nations will, in increasing measure, supply capital funds and capital equipment, trained technicians and other personnel for a united effort in the underdeveloped areas."

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The "underdeveloped areas" are not to be dismissed as merely recipients of materials and machinery, the Advisory Board makes clear.

Some 57 per cent of U.S. imports come from these countries, and 44 per cent of U.S. exports go to them. For the European nations the percentages are even higher.

While world trade has increased, the trade of underdeveloped areas has decreased, but the United States depends on Africa, Latin America, and free Asia for 73 per cent of its imports of strategic and critical materials.

From the Malaya area comes 100 per cent of our supply of natural rubber; from other underdeveloped areas come 80 per cent of U.S. imports of antimony; 77 per cent of our tin, and 85 per cent of our manganese.

Throughout these areas the objective should be not to "mine and get out," the Advisory Board cautions, but "to strive for a balanced economic development" which will lay an enduring base for continued economic progress.

The Board recommended that $500,000,000 be allotted to the Overseas Economic Administration, and that America should work for a new "International Development Authority" in which all free nations would be invited to participate.

THE COLOMBO PLAN

"The Colombo Plan" is a program for British Commonwealth countries and for other nations in South and Southeast Asia, aimed at improving the living standards of 570 million people.

It is an outgrowth of a meeting in London in September 1950, of representatives of Australia, Canada, Ceylon, India, New Zealand, and the United Kingdom. The plan officially started in July of this year, will run for six years, and contemplates an expenditure of 1,868 million pounds.

Of the total expenditure, approximately 34 per cent will be for improved transport and communications, and 32 per cent for improvement of agriculture, including river valley development plans. Some 18 per cent will go into housing, health, and education, 10 per cent for industry and mining, and 6 per cent for fuel and power.

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Widely praised for the "realism" of its programs, and the fact that its aims are limited, the Colombo goals, or "expected results" are summarized officially:

An increase of 13 million acres (3.5 per cent) in land under cultivation;

An increase of 13 million acres (17 per cent) in land under irrigation;

An increase of 6 million tons (10 per cent) in food-grain production;

An increase of 11 million kws (67 per cent) in electric generating capacity.

Main emphasis is upon increasing food production, for the average consumption in this area is well under 2,000 calories a day. Five years after the war food production is still not up to prewar standards, but there are now ten mouths to feed for every nine in 1941.

Before the war, India, Ceylon, Malaya, and Indonesia all imported rice from overseas, and most of their imports came from Burma, Thailand, and Indo-China. In 1938 these latter three countries exported five and one-half million tons; in 1946 this fell to one million. Today it is still less than half the prewar amount.

The Western world finds it hard to translate these figures into human terms.

But in 1943 in Bengal the drop in rice supplies was a main cause of the famine in which well over a million people are believed to have died. The infant mortality in this area is still more than four times as high as in Britain—but the population continues to grow rapidly. By 1970 the population will be 720 million even at the present rate, and today one child in every three born into the world is born in this area.

The present population rate means an additional population in twenty years equal to the whole population of the United States.

How much can these countries help themselves?

A main feature of the plan is a technical exchange program, through which skilled persons may travel from country to country, through which natives may be sent to school in their own countries and in Europe, and through which a cooperative exchange of vital materials can be maintained.

But the official report on the Colombo Plan states:

"The plain fact of the matter is, however, that the countries of South and Southeast Asia are too poor to provide out of their own resources for even the bare minimum of development needed to prevent living standards from falling further. No one could say that the present programs are overambitiouus. India, for instance, has included only half the projects for which detailed plans have been prepared, and Pakistan's program is limited to about 60 per cent of what the government originally hoped to achieve. Even so, it is clear that the programs cannot be carried out as planned unless some help can be obtained from outside the area.

"The countries of South and Southeast Asia need more trained men. To begin with, something over a thousand technical experts of one kind and another — particularly engineers — are known to be wanted for work on specific projects included in the programs of the Commonwealth countries. The countries . . . also need to import more goods from abroad during the next six years than they can hope to pay for out of their own exports."

It is felt that not only machinery, equipment, and capital goods are needed, but food and clothing must also be imported.

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The Colombo Plan places great emphasis on modern tools and techniques in solving the population problem, saying, "Power and machines are the key to plenty on the land . . . here surely is the real answer to our question."

It points out that land under cultivation in the U.S. is only a sixth that in India, but the U.S. uses sixty times as much fertilizer; in the U.S. there are 2,500,000 tractors, in India, 10,000.

Money for the Colombo Plan comes from various sources, including private investment in governments, as well as

industry; sterling balances which India and Ceylon, to mention two countries, built up in London during the war, and loans from the International Bank for Reconstruction and Development.

This latter is a most important source and, except for such projects as U.S. shipment of wheat to India, is the only way in which America is contributing in coordination with the Colombo Plan.

Some observers feel that our emphasis on Point Four, and building of "strength to resist aggression" cannot be nearly so effective in winning the friendship of the peoples of South Asia as would be loans or gifts of men and money to this genuine cooperative operating in regional planning and development.

The *London Economist* has noted that America is contributing through Point Four, that it is the main contributor to the World Bank, and is giving in other ways, but concludes, "It cannot be denied that the final absence of any American contribution to the Colombo Plan would be very regrettable."

POINT FOUR

The "bold new program" is old enough now that inevitably it has become the subject of a "jurisdictional" dispute.

Many high Washington officials, particularly on Capitol Hill, would like to see it transferred from the Technical Cooperation Administration of the State Department, and placed under the ECA. From time to time, it is rumored that the President might simply transfer it to ECA, so long as ECA continues. Others fear that under ECA it would be changed into the industrial type of operation which ECA has emphasized in Europe.

Last year the program received a specific appropriation of $34,500,000. This year the President in his Mutual Security message earmarked no Point Four money as such, but officials estimated that possibly $85,000,000 would go to technical assistance projects.

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An official Point Four report states that it is "swinging into full operation."

In March of this year, the U.S. had concluded Point Four general agreements with twenty-two countries, with a primary emphasis on food supply . . . followed by public health, basic and vocational education, transportation, development of fibers and insecticides, etc.

Point Four is a large and complex program, and is additionally hard to summarize because it consists chiefly of "small" operations designed to add up to large but long-range results. But the dramatic success possible under Point Four techniques are well illustrated in the following excerpts from a report by Horace Holmes of the U.S. Department of Agriculture, who has been in India as agricultural adviser to the United Provinces Government.

"Let us focus our attention on one small area . . . in Northern India . . .

"This covers approximately 100 square miles, and is populated by about 50,000 people.

"Most of the people are farmers, the farms are three acres or less . . . many are tenants who give from half to two-thirds of all that they produce for the use of the land. Farming methods are very primitive . . . well known are malaria, cholera, plague, typhoid, scabies, and typhus . . . 60 to 80 per cent of the males are illiterate . . . thirty inches of rainfall come in the three monsoon months, and practically none at all the rest of the year.

"Here we tested 'extension work' . . . based upon helping people to help themselves. Our first efforts were to find people who wanted to do something constructive—anything; win their friendship and their trust that we sincerely wanted to help them do something that they wanted to do. This little but important step is most essential.

"First concern was improving their yields of wheat. We had a promising wheat, and a few farmers tried this 'Punjab 591.' These trials resulted in an increase of 43 per cent over the native wheat. They weighed, measured, discussed the results, and liked it. The next year complete fields were planted.

"For 2,000 years or longer, there has been little change in the plow. Small turning plows were demonstrated on the farmers' own farms by agricultural workers who could and would plow. They tried it . . . watched the crops . . . liked it. Now they buy the plows from the cooperative, 500 plows were sold last year, but the demand exceeds the supply.

"We brought in 5-tooth cultivators to prepare seed beds at the break of the monsoon. This is an unheard-of innovation, but it not only works well when conditions are right, but increases efficiency from 3 to 5 times.

"A practical composting method was introduced . . . formerly the instructions told the farmers made the simple matter of making compost so complicated that no one would do it. Results were once measured in terms of numbers of pits dug . . . but it is only when the compost is made, put on the land, followed by a crop, that one adds to the food of the villager and the wealth of the nation . . .

"A pair of bullocks represents years of labor and saving to the peasant.

Fourth Point of President Truman's Inaugural Address, January 20, 1949

"*Fourth*, we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas.

"More than half the people of the world are living in conditions approaching misery. Their food is inadequate. They are victims of disease. Their economic life is primitive and stagnant. Their poverty is a handicap and a threat both to them and to more prosperous areas.

"For the first time in history, humanity possesses the knowledge and the skill to relieve the suffering of these people.

"The United States is pre-eminent among nations in the development of industrial and scientific techniques. The material resources which we can afford to use for the assistance of other peoples are limited. But our imponderable resources in technical knowledge are constantly growing and are inexhaustible.

"I believe that we should make available to peace-loving people the benefits of our store of technical knowledge in order to help them realize their aspirations for a better life."

The loss of an animal is a major catastrophe, and hemorrhagic septicemia, rinderpest, hoof and mouth disease, and anthrax were common.

"Training schools were arranged to teach interested villagers . . . some were interested and some were not. By careful handling, farmers in a few villages along the main cattle track were induced to try to protect their animals. In one of these trial villages, one farmer, despite social pressures of his neighbors, refused to have anything to do with this program, and left his three animals unprotected. In that protected village only three animal deaths occurred—those unprotected animals—and the villagers were convinced. Last year over 40,000 animals were protected, and at the close of the season not a single death had occurred due to either hemorrhagic septicemia or rinderpest.

"For the first time it has been proved in India that complete voluntary animal disease protection can be achieved—distressing for those who believe it is only by compulsion that progress can be made.

"In any of the foreign countries where cultures are different, we are likely to make the mistake of attempting to Americanize the people. They do not necessarily want to be Americans . . . they have many reasons to be proud of their own culture.

"When we, as Americans, go out without recognizing the richness of the past of these people, we create enemies rather than friends, and many do far more damage than we are able to offset by technical skill. To strangers in a foreign land, Americans may seem full of energy, wonderful techniques, splendid organizational ability, but without soul. When one studies the East and comes to know the real people . . . he finds a fellowship of mankind that is fine and rich.

"Especially is this true with those connected with the soil, schooled by the same teacher . . . it is necessary to give practical help in a spirit of friendliness and understanding, aimed not at imperialistic objectives, but at the human rights and yearnings of people."

ECONOMIC COOPERATION ADMINISTRATION

In terms of European aid, where $869 million is allotted for the fiscal year 1951, the total of $108 million the Economic Cooperation Administration will spend in Southeast Asia seems small.

But officials point out that Asia's "capacity to absorb capital is limited"; in terms of dollar requirements her needs are small compared to European operations, and the problem is not lack of dollars, but lack of managerial, technical, and other resources.

Of the amount allotted, $40 million will go to Formosa and $44 million for the "general area of China." That phrase means Formosa, Thailand, Burma, and the three states of Indochina.

The land area involved is about one-third of the United States, and the population is approximately 146 million, but it is not an area of general poverty.

Equally important with the problems of "self-support" for these peoples, a recent report states, are the goals of "self-government and self-protection."

FORMOSA

Commodity Imports:—The commodities being imported consist largely of industrial raw materials, tentatively programmed at approximately $30 million.

Industrial Rehabilitation:—This is directed toward the improvement of power generating and transmitting equipment, railway transport, telecommunications, highways, and fertilizer manufactures. The hope is that Formosa could be economically self-supporting within five years.

Rural Reconstruction:—This program, under a commission of both Chinese and American members, is administering 160 projects intended to better the agricultural economy, and rural living conditions. It is largely locally financed.

INDOCHINESE STATES

The well-entrenched internal rebellion of the Viet Minh has disorganized these countries, and the normal food surplus has vanished—there is practically no export of the corn it once shipped to the French colonies and China.

The primary objectives here are political and military, and the U.S. is providing military assistance to the Associated States and French forces.

A special Technical and Economic Mission was established and over six million has been committed of a total of 21 million dollars. The aid includes: rural rehabilitation, public health and sanitation, specific programs for malaria, venereal diseases, trachoma, and hospital equipment; sending of students for technical training in the U.S.; development of power, transportation, and small shipping craft; and sending supplies of essential commodities such as raw cotton, rope, drugs, galvanized sheeting, and petroleum products.

BURMA

This newly independent country, impoverished by ten years of war and revolution, is officially described as "in need of every kind of aid."

Its rice exports are a third of prewar, and its internal disorders prevent its shipping out its lead, tin, zinc, petroleum, and teak which the world so greatly needs.

ECA is helping to rebuild the ruined port of Rangoon, which once handled 80 per cent of Burma's seaborne trade; is aiding projects for inland waterways improvement; working on flood control and irrigation projects, rehabilitating rice mills, etc.

Public health services are being rebuilt virtually from the ground up, and agricultural services are starting programs for livestock disease control, plant disease and rodent control, seed improvement, etc.

A commodity program is also under way, and the total of ECA funds for this fiscal year is in excess of ten million.

THAILAND

Thailand is a vastly underdeveloped country, with a poor and illiterate people, millions of them weakened by malaria and other controllable diseases.

Many areas are impoverished for lack of irrigation and reclamation programs; transport and power facilities are largely primitive.

ECA is working on "a modest net addition" to the country's resources, on condition that they be matched by local resources and "directed toward remedy now, without delay, of some of the weakest spots in the social economic structure."

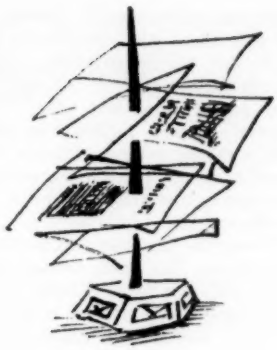
The country is torn by internal and external Communist pressures, and the Thai government is believed to be making firm and effective efforts to improve its army and defenses.

ECA aid here is mainly to strengthen the country's security, through power and transport development, and through improvement of popular morale by means of public health and agricultural services. The total annual expenditure here is short of ten million.

—M. A.

AEC CONTRACT POLICY AND OPERATIONS

NINTH SEMIANNUAL REPORT OF THE USAEC: PART TWO



Summarized by BENNETT BOSKEY

In the last issue, we presented a condensation of Part One of the Ninth Semiannual Report. Bennett Boskey, former Deputy General Counsel of the AEC, presents below a summary of Part Two of this latest report.

IN ITS Second Semiannual Report, submitted to the Congress in July 1947 after the initial six months of operation under a civilian commission, the AEC drew attention to the fact that it was conducting its activities through a large number of contractors and that none of its major production and research programs was carried on by direct commission operation. This contractor system, which was the pattern inherited from the Manhattan Engineer District, seemed to the commission in its early days to provide the greatest promise for obtaining wide participation in the atomic energy program from many and varied segments of American life.

Part Two of the commission's Ninth Semiannual Report now reviews AEC contract policy and operations from the vantage point of four full years of experience. It states that "probably the commission's most important administrative decision" has been to continue the Manhattan Engineer District's practice of contracting with industrial concerns and academic institutions to perform the actual operations.

Pointing out that the atomic energy program, more than any other in the United States government, is carried on through contracts with private organizations rather than by direct government operation, the AEC states its hope that this fifty-page summary of contract policy will help to widen participation of all segments of the economy in the program. It is made clear that today, just as it was four years ago, the enlistment of a large and growing cross-section of industry in the many phases of atomic energy activity is one of the commission's prime objectives.

It will be recalled that the Atomic Energy Act of 1946 left to the commission a choice between the method of direct operation, such as has become familiar in the activities of the Tennessee Valley Authority, and the method of contract operation, which was utilized throughout the atomic project during the war, or some combination of the two. In entrusting to this newly created administrative agency the vast responsibilities covered by the statute, the Congress thus gave to the commission power of decision as to the *modus operandi* by which the programs could best be accomplished. Circumstances have persuaded the commission continuously to exercise its judgment in favor of the method of contract operation.

REASONS FOR THE POLICY

In summarizing the reasons underlying this basic policy determination, the commission notes first that, when it took over the enterprise in 1947, the atomic facilities throughout the country were being operated capably under contracts; the impairment or even stoppage of production that might have resulted at that time by terminating the contracts and shifting to direct government operation involved risks too grave to be accepted. Upon several subsequent occasions the possibility of direct operation has been studied when new major projects were about to be undertaken; the commission reports that in each case it has appeared that the project would be advanced more rapidly and efficiently by an experienced industrial concern with its highly developed managerial talents.

Fundamental to the commission's system of contract operation has been the consistent view of its original members and their successors that the unique capacity of American industry to develop new, better, and more economical ways of doing things is one of the greatest advantages our nation possesses in atomic energy development. The commission also looks to the contract system to lay some groundwork for eventual termination of government monopoly and for the integration of atomic development with the competitive private enterprise system. Industrial participation is described as a two-way street; the national program draws upon the managerial skills of industry, and industry acquires special technical knowledge which, under the present necessities for controlling atomic information, is obtainable in no other way.

THE KINDS OF CONTRACTS

This is the general frame of reference for Part Two of the Ninth Semiannual Report. As is well known, the diversity of the commission's work necessarily calls for a wide variety of contractual arrangements. These range from contracts for the operation of the weapons facilities at Sandia, New Mexico, or town management at Oak Ridge, Tennessee, to the procurement of standard supplies or a simple contract for a small university-type basic research project.

An effort has been made in this report to paint with a broad brush in order to give a general coherent explanation based on the major categories of contracts. Refinements, special arrangements, and exceptions to policies have been for the most part omitted; the result is a summarization which has general validity even though on specific points, and some-

times important specific points, many an individual AEC contractor might feel that the description was not strictly applicable to his operation. The report does not offer a large amount of new information on the AEC contract system; rather it brings together in one place a picture of the contracting methods followed and the results sought.

Under the law, the Atomic Energy Commission has wide latitude in its use of different types of contracts and may shape the particular contract instrument so that the contractor will be enabled to do the most effective job. Successful use of the contract system requires continuing attention to the question of striking the best balance between freedom of action on the part of the contractor so that the country can get the maximum benefit from his managerial initiative and knowhow, and supervision on the part of the commission so that the program as a whole will not suffer from lack of direction or coordination and the commission's responsibility for the use of appropriated funds can be adequately discharged. The report thus gives some examples of the manner in which the commission, through its program divisions, supervises the scope of the work to be carried out by the contractor and coordinates the work of different contractors whose fields of activity must be meshed together if the commission's production and development schedules are to be met.

In December 1950, the commission issued a codification of what it regarded as sound practices in the form of an AEC Procurement Policy Guide, which covers procurement of services, supplies, materials, and equipment by AEC and its cost-reimbursement contractors. The guide favors the accepted federal policy of open competitive bidding on a lump-sum or unit-price basis with awarding of contracts to the lowest responsible bidder. But it likewise recognizes that advertising of requirements and public solicitation of bids will at times not be possible. For example, considerations of security, urgency of work, or complex design which must be worked out during the term of the contract, may make it impracticable or unwise to let contracts by advertising. In such circumstances AEC officials are directed to take steps to assure that adequate consideration is given to qualified available firms before final selection is made of a contractor.

From the report it appears that unit-price contracts have been used widely in the processing of uranium through the feed materials stage, and in many of the commission's construction projects it has been possible to let lump-sum contracts based on standard contract forms. A special type of lump-sum contract arrangement has even been developed for relatively small research projects.

KOREAN APPEAL FOR TEXTBOOKS

WASHINGTON, D.C.—South Korea now has 400,000 secondary students and 15,000 college students who are being taught on hillsides and along railroad tracks. The Communist invaders destroyed all South Korean textbooks and substituted Marxist ones, which were destroyed in turn by the South Koreans.

George Paik, South Korean Minister of Education, has asked for help to get textbooks for the reopening of school this fall. Funds and inquiries should be sent to him at this address: Dr. George Paik, University of California, Berkeley, California.

MAJOR OPERATION CONTRACTS

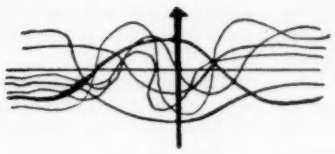
At the same time it is made evident that the commission's major operations, under which contractors carry on the work at its more important laboratories and production installations, as well as a significant portion of the new construction are subject to contractual arrangements of the cost-reimbursement type. This is true, for example, of the General Electric contract, which covers activities at both Hanford and the Knolls Atomic Power Laboratory, the Carbide contract at Oak Ridge, the DuPont contract for the Savannah River project, the University of California contract for Los Alamos, the University of Chicago contract for Argonne National Laboratory, and many others. These are operating or construction ventures which are so beset with uncertainties of cost and time, or even of scope, that it is felt not feasible to have the work performed on a lump-sum or unit-price basis. During a period of national emergency the renewed emphasis given to urgency is bound to increase the number and proportionate significance of the negotiated cost-type contracts. Some of these contracts include provision for a fee and others stipulate that the work shall be performed without profit, although agreement is generally made that the government shall bear some allocable part of the contractor's overhead expenses.

In describing the administration of its major contracts, the commission gives considerable emphasis to the integrated accounting methods worked out over the past four years with the full cooperation of the General Accounting Office. These have involved noteworthy forward steps in government accounting which may produce beneficial effects on the administration of contracts by other government departments as well.

There is also furnished a summary of the reporting system which supplements personal discussions between representatives of the commission and its contractors as a means of keeping the commission informed on the concrete results that are being achieved by the expenditure of its appropriated funds. Specific types referred to are cost reports (which are of particular importance on construction projects), monthly progress reports under applied research and development contracts, end-of-the-year reports on basic research projects, and the special accountability reports required for all source and fissionable materials. A few paragraphs are added concerning the relationship between the commission and its contractors on security matters.

The final chapter recapitulates the interesting developments in the handling of labor relations of AEC contractors. This is by now a relatively familiar story; it involves an important phase of the commission's activities and has resulted in the establishment of special machinery (a Presidentially-appointed Labor Relations Panel) and procedures designed to avoid work stoppages in atomic energy operations, which perhaps will prove suggestive of techniques that could be applied in other vital industries. The report concludes with a review of the very enviable safety record which has prevailed throughout the operations at commission installations.

REPORT ON THE BRITISH ATOMIC ENERGY RESEARCH ESTABLISHMENT



An Editorial Note by Sir John Cockcroft

The Atomic Energy Research Establishment at Harwell was founded in January 1946, and construction work began about four months later. The greater part of the buildings are now completed and its major equipment is installed and working.

The establishment now works in the general field covered by the Argonne, Brookhaven, and Oak Ridge Research Laboratories of the United States Atomic Energy Commission, and is of the same general size as one of those laboratories. During its five years of growth, a good scientific and technical staff has been built up in the fields of chemistry, chemical engineering, metallurgy, and physics.

The Medical Research Council has also established a Radiobiological Research Unit at Harwell.

The account which is given here of the work of Harwell is far from complete; there has necessarily been a rather limited and arbitrary choice of topics. Emphasis has been placed on the scientific rather than the technological aspects of the work, since the security classification of much of the technological work makes treatment difficult.

PHYSICS

Dr. T. G. Pickavance

In a large establishment concerned with atomic energy, the work done by physicists naturally covers a very broad field, ranging from technological assistance to basic nuclear research. As in other sections of this article, it seems desirable to concentrate on a few examples of the activities of physicists rather than to attempt to survey the whole. In particular, applied work, such as reactor physics, will not be discussed.

Turning first to nuclear physics, there are at Harwell several particle accelerators which can be used for research. The largest of these is the 110-inch frequency-modulated cyclotron, which has been operating since December 1949. This is used to accelerate protons to maximum energy of 175 million electron volts (mev) with a mean proton beam current of around 1.5 microamperes. Beryllium, carbon, aluminum, and uranium have been used as targets, and the neutron production from these substances under bombardment with protons has been studied. The energy distribution of neutrons from all these elements has been found to show a pronounced peak near the maximum value permitted by the energy of the bombarding protons. The neutrons produced in this way from beryllium, with an effective energy of 156 ± 3 mev., have proven particularly suitable for measurement of total cross-sectional areas with which different atoms oppose the passage of neutron beams. These "neutron total cross-sections" have been determined for hydrogen and nine other elements. The cross-sections of hydrogen and carbon atoms have also been measured for neutrons of several lower energies.

Another aspect of the high energy accelerator program at Harwell is the development of so-called "traveling-wave" linear electron accelerators. A 3–4 mev. model of such an accelerator has been in use for some time. The radio-frequency source of the "traveling-wave" is a 2 megawatt, 10 cm. magnetron, and the electron acceleration takes place in a corrugated copper waveguide. This accelerator now forms part of a time-of-flight neutron spectrometer. The accelerated electrons strike a target, causing the production of gamma rays; these in turn are used to disintegrate beryllium or deuterium, producing neutrons whose energy is then determined by timing their passage between two points. The apparatus has already been tested by measuring the velocity of neutrons belonging to well-known resonance groups, and good agreement with previously published data has been obtained.

Following the success of this small linear accelerator, a larger 15 mev. machine is now being built; this will give a greatly enhanced output for neutron spectrometry; other 15 mev. models are expected to be valuable for medical work. A more efficient traveling-wave accelerator, for much

In the following articles, leaders of five departments at Harwell, England's laboratory for atomic energy development, describe the work of their groups. The Bulletin is indebted to H. A. C. McKay of the chemistry section for assembling these contributions. The review supplements an earlier article on the Harwell Establishment by H. W. B. Skinner in the April 1948 issue of the Bulletin. It does not deal with the progress in pile construction and atomic weapon development in Britain since 1948; the Bulletin hopes to present a report on these aspects of the program in the near future. The present review is somewhat more technical than is usual in the Bulletin; but we believe many of our readers will appreciate it. Papers describing the Norwegian and Canadian projects appeared in the May 1950 Bulletin, and the work of the French Atomic Energy Commission was reported in the Bulletin issue of October 1950.

higher energies, which will use a dielectric loaded waveguide, is being designed.

The Harwell establishment also has two 30 mev. electron synchrotrons. The electron beam has been extracted from one of them for direct use in experiments, while in the other the electrons strike an internal target and produce high energy x-rays. The development of both machines is continuing while they are being used for nuclear research. Investigations of nuclear disintegrations caused by high energy x-rays have been made, with both photographic emulsions and counters used for detection. For example, the emission of alpha particles from boron, carbon, nitrogen and oxygen, irradiated with x-rays ($\gamma\alpha$-reactions) have been studied by the photographic emulsion technique. The photo-disintegration of lithium 7 into a triton and an alpha particle, or into a proton and helium 6, have also been observed.

Other machines available for nuclear research are a pressure-insulated van de Graaff generator, and a 200-thousand-volt Cockcroft-Walton electrostatic accelerator. The van de Graaff machine has been in use for about a year, producing a beam of protons up to 1 microampere and 3 mev. energy. The 200 kv. accelerator has been used in investigations of D-D and T-D reactions (bombardment of deuterons by deuterons or tritons).

Besides the high energy accelerators, associated equipment and techniques for physical experimentation have also been developed at Harwell. For example, a "magnetic lens" beta ray spectrometer has been constructed for measurements of beta ray spectra. With ring focusing, and counting the analyzed beta rays in a proportional anthracene scintillation counter, it has been found possible to measure the high energy beta spectrum of gold 198, although it corresponds to a mode of distintegration that occurs only in one out of ten thousand disintegrating nuclei of this type.

Along these lines, a useful development has been the application of proportional counters, of moderate size, with an axial magnetic field, for measurement of electron energies up to several hundred thousand electron volts. Deflection by the magnetic field enables long electron ranges to be confined inside the counter; the effect of the magnetic field on the amplification of the ionization current in the gas and the proportionality of the counter can be made negligibly small.

In other work on detectors, a mu-meson counter has been made to operate by allowing the "Cerenkov radiation," produced when the meson passes through a cell containing distilled water, to fall on a photo-multiplied type vacuum tube.

On the production side, as distinct from pure research, the physics divisions are concerned with one aspect of the isotope program. Carbon 13 and oxygen 18[1] are prepared by isotopic enrichment of carbon monoxide through fractional distillation process; 2.8 grams of carbon 13 are produced in this way per week. Milligram quantities of isotopes of light elements are produced in a small electromagnetic separator, and larger quantities (or, alternatively, better separations) are now obtainable with a larger instrument of the same type. These products, in common with the radioactive isotopes produced in the pile, are available for shipment to users outside the Harwell establishment.

CHEMISTRY

H. A. C. McKay

The main aim of the Chemistry Division of Harwell is to provide the background of chemical knowledge needed for the development and operation of British plutonium production piles, reactors, and uranium and plutonium extraction plants. There is a broad grouping into operational and scientific sections, the former being concerned with making processes work, and the latter with understanding their chemistry. The production of radioactive isotopes is handled by a separate Isotopes Division which now supplies isotopes to twenty-five different countries. Some research on methods of isotope preparation has, however, been carried out within the Chemistry Division.

On the operational side, the chemists concerned have to be familiar with flow sheets and other plant details; they mantain day-to-day contact with the pile operators, the Chemical Engineering Division, and outside firms; and their experiments naturally tend to be of a somewhat *ad hoc* character.

The scientific groups often tackle problems suggested by operational developments, but their terms of reference are wide, and no problems in radiochemistry, radiation chemistry, or heavy element chemistry lie outside their scope. A representative selection of their work was presented at a joint symposium with the Chemical Society in 1949, and progress has accelerated since then.

Of topical interest are various researches bearing on the "actinide problem."[2] One question at issue is whether thorium is a true actinide, with analogies to cerium and uranium, or a member of the group IV-A of the periodic table, comparable with zirconium and hafnium. Studies of the lower halides of thorium, most of which were previously unknown, point to the latter view. We may cite in its favor the existence of the halides of divalent thorium, $ThCl_2$ and ThI_2 (attempts to prepare $ThBr_2$ are still in progress), as well as of the halides of trivalent thorium, $ThCl_3$, $ThBr_3$, and ThI_3. Other pointers in the same direction are that the iodides are easier to prepare than the chlorides, and especially that the crystal structure of thorium tribromide resembles that of bismuth triiodide, but is totally different from that of uranium tribromide or trichloride.

In the case of uranium, on the other hand, measurements of atomic magnetism have given definite evidence of an actinide structure, by in-

[1] These isotopes of oxygen and carbon are stable, but their content in normal oxygen and carbon is very low. Since radioactive carbon often is inconvenient to use, and since no useful radioactive isotope of oxygen is available, these stable "tracers" are very useful research tools.

[2] The "actinide problem" concerns the chemical nature of the heavy elements with atomic numbers of 89 and higher. The possibility exists that these elements may form a series with very similar chemical properties, analogous to the "rare earth" or "lanthanide" series in the preceding period of the periodic system (lanthanum, cerium, etc., atomic numbers 57, 58, . . .). The lanthanide series arises because, in every step in this series, an electron is added into an interior electron "shell"—the so-called "4f" shell. Since this shell is well hidden inside the atom, this addition leaves the chemical properties almost unchanged. The actinides would be characterized by the presence of similarly hidden "5f" electrons. The alternative is for these elements to be built up by addition of electrons into outside shells, such as the "6d" shell—thus causing definite changes in valency and other chemical properties from element to element.

dicating that electrons are present in the 5f-shell. In uranium dioxide, tetrafluoride, tetrachloride, and tetrabromide, the uranium atom has been proved to contain two 5f electrons, while tribromide and triiodide probably contain two 5f and one 6d electron. It is interesting to note that the magnetic susceptibilities of the tetrahalides are all very similar, although the extent of covalent bonding of uranium to the halide increases steadily from fluoride to bromide. This suggests that the 5f electrons are not involved in bond formation in these compounds.

It has been suggested that covalent bonds involving f-electrons do occur between uranyl and nitrate groups.[3] The solubility of uranyl nitrate in ethers and other organic solvents, and the formation of the unusual complex ion $UO_2(NO_3)_3$ indicate that there is something novel about the interaction between these groups which has no complete parallel among the lighter elements.

In the radiochemical field, a significant advance is the discovery of thirteen new isotopes produced by gamma rays (γ, n– and γ, p–reactions) using the Malvern synchrotron as a source of 23 mev. gamma–rays. All but one of these are in the range of atomic numbers from 62 to 79. It is perhaps surprising that so large an addition to the list of known isotopes can still be achieved by so simple a method.

Various applications of radioelements to chemical problems have been made by tracer and other techniques. The rate of self-diffusion in tungstate solution has been studied with the aid of radioactive tungsten, and the decrease in this rate with increasing acidity has been correlated quantitatively with the known polymerization of tungstate to hexa– or heptatungstate. Improvements have been effected in the Hahn emanation method, greatly increasing its sensitivity and speed of response, and new features in diffusion processes, and allotropic changes in such oxides as alumina, have been brought to light thereby; some of these can be neatly correlated with very recent work showing the complexing of the aluminum oxide system. The use of Bepo[4] for radioactivation analysis[5] has started, and includes the determination of rubidium in potassium salts; of hafnium in zirconium; of niobium in tantalum and vice versa; and of arsenic in samples which appeared arsenic-free by all other tests.

METALLURGY

Dr. P. C. L. Pfeil

The economic development of atomic energy for industrial use depends upon the solution of many metallurgical problems. Of these, we may mention the development of efficient methods for extracting uranium and plutonium, the fabrication and jacketing (canning) of these metals or their alloys to produce nuclear fuel elements suited for use in high temperature reactors; the development of new structural materials for reactors, and the solution of corrosion problems introduced by the use of liquid metals as coolants. Many of these problems, considerable enough in themselves, are further complicated by the necessity of taking into account the effects of radiation.

Such technological developments are an essential part of the work of the Metallurgy Division at Harwell, but this is allied to an equally strong effort to gain fundamental knowledge of the properties and behavior of metals and ceramics. It is examples of these latter researches that are briefly given here.

The deformation phenomena in uranium metal are much more complex than in other metals. X-ray and polarized light examination of coarse-grained-alpha-uranium[6] produced by strain-annealing, shows that when uranium deforms under stress it does so on three distinct families of plane by twinning, and on two others by slip. The one chiefly concerned in twinning is the (130) plane. The second is the (112) and the third, a plane of irrational index very close to (172). Slip occurs on the (010) plane, parallel to the (100) direction. The (010) plane is not the most closely packed plane, but it contains sheets of atoms bound covalently. The closest packed plane, (110), also shows slip.

Attempts are being made to extend the theories of Hume-Rothery, Raynor, and others to the alloys of the heavy elements. This has involved some modifications of previous conceptions. For example, changes of valency are uncommon in lighter elements, but an apparent variation in the valency of uranium is an important factor in understanding its behavior. Evidence from crystal structure and solid solubility studies suggests that alpha uranium is quadrivalent, whereas the gamma modification of uranium is hexavalent. The effective valency of uranium in intermetallic compounds may vary with the amount and nature of the alloying partner; a survey of intermetallic AB_2 type compounds in uranium alloys with the transitional metals, suggests that uranium may behave as a divalent element in this type of compound. The knowledge so far acquired assists in predicting the constitution of heavy metal alloy systems.

Diffusion of atoms in metallic crystal lattices is a little understood phenomenon of vital metallurgical importance. The complexity of the diffusion process can be judged from the following example of one of the apparently simple cases which has been studied. Copper and nickel atoms are very nearly equal in size, and the metals are soluble in each other in all proportions. When these two metals diffuse into each other, however, three interesting phenomena have been observed. First, marked preferential diffusion of copper occurs along the nickel grain boundaries, but not at twin boundaries. Second, inert markers placed at the original interface of the two metals move bodily toward the copper-rich side; this effect, first noticed by Kirkendall in other diffusing systems, has been tentatively explained by suggesting that copper diffuses more readily into nickel than nickel into copper. Third, as diffusion proceeds, a large number of small holes are created in the diffusion zone. Experiments on self-diffusion (diffusion of a metal into itself, which is susceptible to study by radioactive tracers), and on diffusion in very dilute solid solutions are now in prog-

[3] In the lanthanide series, the 4f electrons appear to be inert as regards chemical binding. It would therefore be interesting to find the 5f electrons participating in covalent binding in the actinide elements.

[4] Bepo is one of the experimental nuclear reactors in Harwell.

[5] See article by Eugene P. Wigner, "Impact of the Developments in Atomic Energy on the Sciences," *Bulletin*, VII (March 1951), 66.

[6] Metallic uranium is known to exist in three different allotropic modifications, known as alpha uranium, beta uranium, and gamma uranium.

ress in an attempt to elucidate the phenomena involved in these simplest cases.

Experiments are in progress to determine the effect of irradiation by fast neutrons, gamma rays, etc., on the strength of pure metals and, subsequently, on alloys of increasing complexity. Two experimental techniques have been used. In the first, a method has been worked out for measuring the rate of creep (slow deformation) of aluminum while it is being irradiated in the pile. In the second case, the damage done by irradiation to a metal lattice has been "frozen" in the metal by carrying out the irradiation at -150°C. At these temperatures, thermal energy is insufficient to allow the disturbed atoms to diffuse back into normal lattice positions.

In the ceramics field, two studies may be quoted. It has been shown that the viscosity of some oxide "slurries" (aqueous suspensions of oxides) depends upon the acidity of the medium. For uranium dioxide and alumina slurries, the viscosities have minima at certain acidities (pH 3 to 4). The viscosity curves have been quantitatively explained on the assumption that the viscosity is a measure of the effort required to shear water films, absorbed on the solid particles of the slurry. The number and strength of binding of these films are determined by the density with which charged ions are initially adsorbed on the free surface of the uranium dioxide (or alumina) particles. Since these oxides are amphoteric (that means, they can carry both positive and negative charges), the ions adsorbed may be either positive (M+) or negative (MO− radicals), where M means metal (uranium or aluminum). For such amphoteric oxides, it can be shown that the nature and concentration of the ions in the medium is a function of the acidity of the solution, and this variation has been shown to be similar to the observed variation of viscosity with acidity.

The main concern of fundamental research on sintering (elimination of voids in compacted powders by heating) has been to determine the effect of introducing defects into oxide crystal lattices. In some cases, such defects can be produced by carrying out the sintering in an oxidizing or a reducing atmosphere. It has been shown that certain non-stoichiometric oxides (oxides whose atomic composition cannot be represented by small whole numbers), for example, $UO_{2.2}$, sinter very much more rapidly than the corresponding oxides of stoichiometric composition, in this case, UO_2. This has been attributed to the formation of strain centers in the lattice around the excess oxygen ions, which occupy positions between the regular crystal planes, thereby permitting diffusion to take place more rapidly than in the perfect or ideal lattice, with a consequent increase in the rate of sintering. Reaction rate theory has been successfully extended to cover sintering of ceramic oxides, and calculation of the free energy of activation from the experimental data on the sintering of UO_2, $UO_{2.17}$, MgO, and Al_2O_3 has shown a direct correlation with the temperature of complete sintering.

CHEMICAL ENGINEERING

A. S. White

Chemical engineering is often regarded as having closer ties with full-scale industrial operations than with laboratory research. This may be so in well-established industries, but in new industries with an undeveloped technology, chemical engineering must be much closer to the research laboratory than to the works. For this reason it is natural to find chemical engineering inside the Atomic Energy Research Establishment. The development of atomic energy provides scope for the chemical engineer at all stages, not only in the development of processes from the laboratory to the pilot and full scale, and in the improvement of design methods for operations specifically useful in these processes, but also for contributions of value to industry generally.

The interests of the Chemical Engineering Division include mineral dressing as applied to the beneficiation of low-grade uranium ores, the chemical processing of irradiated material, the development of the technology of reactor materials, and the fundamental study of the operations of special interest to the new industry. These interests are linked together through the common employment of similar operations in the processes involved.

The primary function of the Mineral Dressing Group is the investigation of methods for the treatment of low-grade radioactive ores. Its laboratories are well equipped for this purpose both with the usual apparatus of mineral dressing and the mineralographic equipment for the evaluation of the products. A number of ores from British Colonial sources are under investigation. The techniques of mineral dressing are proving useful in other directions also. An interesting example is the isolation from "Kish," a graphite-rich product of the iron industry, of a quantity of graphite for comparison with natural and artificial graphites from other sources. By magnetic separation and flotation, a concentrate containing 90 per cent graphite was obtained, which by simple hydrochloric acid treatment gave a satisfactory product containing 99 per cent graphite. This process is much superior to alternative chemical processes which involve heating under pressure with caustic soda.

Nuclear reactors for power production will require materials which will stand high temperatures. It is necessary therefore to produce such materials for the determination of their nuclear and other properties, and also to develop methods of their fabrication and handling. Beryllia, for example, has potential value both as a "moderator" to slow down neutrons, and as a refractroy, but it has a very unpleasant physiological reputation and must be handled in special equipment designed to eliminate dust hazards. A special laboratory has been built in which all operations are carried out under "dry-box" conditions. Here beryllia ware is produced by slip-casting and pressing techniques, both as a service and as a means of determining the conditions for the production of articles with the required physical properties.

Zirconium is a metal of interest to the metallurgist, but if it is to be of use for reactors it must be free from hafnium, with which it is always associated naturally. Ion exchange and solvent extraction methods have been used for the preparation of small amounts of hafnium-free zirconium compounds for further investigations by other divisions. This work provided an interesting exercise in the use of tracer and radioactivation methods for the control of processes to which conventional analytical methods are not easily applied.

Sodium-potassium alloys have properties which make them of interest as possible coolants for power reactors. These alloys, however, require careful

handling because of their high chemical reactivity, and before they can be used it is necessary to develop foolproof techniques. Contamination of the alloy must be avoided if it is to give good service, so it is necessary to provide a really clean circuit before the alloy is introduced, and to maintain plant, valves, pumps, etc., in leakproof condition. Something beyond what is satisfactory with mercury, Dowtherm, and similar liquids now used in industry must be achieved, and one section of the Chemical Engineering Laboratory is therefore devoted to developing the technology of the use of the sodium-potassium alloys. A thermosiphon system circulating the alloy has been operated for many hundreds of hours and techniques for cleaning the alloy by filtration have been used successfully. The development of electromagnetic pumps, in which the alloy itself is set in motion by induction currents, and in which there are no moving parts, has achieved some success, although efficiencies are still low. This type of pump can also be used with mercury. The behavior of liquid metals in magnetic fields is being studied, using mercury, to obtain fundamental information to supplement that obtained with the pumps themselves.

Interest in these new materials does not displace interest in graphite and heavy water. For example, the laboratory is equipped to produce small shapes in graphite from a variety of raw materials, and the effect of raw material and processing conditions on the physical properties of the artifacts is being studied with the object of improving graphite quality still further.

Perhaps the most important problems facing the chemical engineer are those associated with the processing of the nuclear "fuel" in order to remove the fission products and recover the fissionable material for re-use. Besides the separation processes themselves, there are problems of how to treat and dispose of the liquids that have been used in separations. These problems must be overcome before full-scale, or even pilot-scale operation can be undertaken. These liquids often are highly radioactive and require remote handling and control through shielding. Thus the pilot plant and process group has the task of developing not only the process itself, but also equipment which is capable of satisfactory remote operation behind shielding. As far as process development is concerned, the object is to work on the smallest possible scale which will give confident design information, using the pilot plant proper for testing equipment and for the final proving of a selected process. Some measure of success has already been achieved and is reflected in a saving in time and material.

The above should be taken not as a picture of the complete program but only as examples of the interest of the Chemical Engineering Division. Other work in progress covers the fields of ion exchange, solvent extraction, sedimentation, filtration, absorption, evaporation, and distillation, in fact, almost the whole range of the unit operations. In the Atomic Energy Research Establishment, there is a difficult and fruitful field for the chemical engineer.

BIOLOGY

Dr. J. F. Loutit

The medical research group at Harwell has been engaged in research in those fields appropriate to an atomic energy establishment. Besides fundamental studies, one group has engaged itself particularly with the study of methods of protection of normal tissues against the damaging effects of radiation.

The last few years have been particularly fruitful in this latter field. If ionizing radiations exert their actions purely through physical mechanisms as had once been postulated, there would seem to be no possible measure of defense except prevention of access of radiation to the tissues. If, however, the whole or part of the action is through intermediate chemical reactions, it is possible to envisage some form of protection through providing the tissues with non-toxic chemical substances which will compete with the sensitive tissue substance for the noxious chemical agents formed by the radiation. On the theory that much of the damage to tissue is through the production of hydrogen peroxide and free hydroxyl radicals, a number of laboratories have been examining various oxygen-binding substances for their protective effect. At Harwell, it has been found that two substances have a significant effect, namely, thiourea, which was known to protect *in vitro* certain isolated, purified enzymes, and sodium ethane dithiophosphonate, which is an analogue of a substance known to be partially protective against the effect of mustard gas.

Further possibilities of protection exist in virtue of physiological differences in sensitivity of cells of different degrees of specialization. A notable advance in this direction having been made in Chicago, the Radiobiological Research Unit is actively following this line of investigation.

Many of the dangers of radiation in the development of atomic energy devolve not from radiation given externally to living organisms but from internally deposited radioactive substances, particularly those which localize metabolically in bone, from which their release is extremely slow. A survey is, therefore, being made of the physico–chemical and metabolic pathways by which these substances, notably strontium (because of its chemical analogy to calcium in the bone) are taken up by and withdrawn from the bone tissue.

No study of the biological effects of radiation would be complete without reference to the effect on the hereditary material of the nucleus, the chromosomes and their constituent genes. In spite of the intrinsic difficulties of the work, in which positive results can only be observed after one or many generations of breeding, some useful negative results have so far been obtained in mice; also for the first time a complete mapping of the chromosomes in the reproductive cells of the mouse has been completed. This introduces a powerful new tool for cytogenetic study and allows the recognition of abnormal chromosomes in mice to be made visually instead of requiring, as formerly, time-consuming breeding tests.[7]

While active work has been going on in the laboratories, a number of the staff have of necessity had to expend much time in theoretical considerations of problems of tolerance or maximum permissible doses of various forms of radiation and radioactive substances. This work will be the foundation on which regulations of the Radioactive Substances Act will be based.

[7] This work is being carried out at the Institute of Animal Genetics, Edinburgh.

CIVIL DEFENSE NEWS

Prepared by ARTHUR H. JAFFEY

CD VOLUNTEERING LAGS

Federal and city officials have now undertaken widely publicized drives for volunteers, but not a single American city has filled the quota planners believe necessary. Of the fifteen million persons Millard Caldwell, FCDA Director, says are necessary, only five-hundred thousand have enrolled. Even in New York City, which leads the nation, Grover Whalen, head of Recruiting, and an enormous amount of posters, radio appeals, and the cooperation of schools and police stations have brought in only about 25 per cent of the city's needs.

CONGRESS SLASHES CD FUNDS

Civil defense officials are extremely worried about the doubt surrounding civil defense appropriations, not only because of the need for the money, but because congressional action has dampened the spirits of the persons who have gone to work in local civil defense organizations.

Early this year the federal agency submitted a request for $403,000,000, and after much backing and filling Congress appropriated only $31,750,000. Mayor Frank P. Zeidler of Milwaukee, who has been a pioneer in civil defense and has even mapped a partial dispersal program for his city, prepared a letter of protest which was adopted by the American Municipal Association.

"Civil defense is either necessary or it is not," the letter said, and it approved a $550,000,000 appropriation for the current fiscal year. It asked that "Congress make the decision quickly. Unless it does the civil defense program will disintegrate rapidly."

The President and the federal agency had envisioned $250,000,000 to be spent, and another $250,000,000 to be matched with it by states and cities, for building bomb shelters or remodeling existing buildings, basements, and subways. Another $200,000,000 was to be marked for stockpiles of medicine, medicinal supplies, and disaster supplies and equipment.

THERE IS NO DEFENSE

The importance of "passive defense" (CD), since no certain "active defense" has been developed for protection against enemy air attack, was dramatically shown in a three-day nationwide air defense exercise.

"'Enemy' Planes Penetrate U.S. Defense at Will," was the *New York Herald Tribune's* headline, and its story explained that low clouds and poor visibility permitted many low-flying "enemy" planes to penetrate to leading cities, undetected by spotters or radar. Of course, many civilians heard the planes roar over in the early morning hours, but were not conscious of the test, so officials called for more volunteers for the volunteer ground observers corps which reports to the air force.

Major General Frederick H. Smith, who commands the Eastern Air Defense, said "The widespread bad weather of Saturday, when many of the penetrating aircraft operated at low levels under the range of radar, shows the need for a ground observation corps. We do not claim that radar would entirely stop every attacking aircraft before it reached its target." He also called for more army anti-aircraft guns for close-in or "point" defense of important centers.

"LET'S NOT UNDERESTIMATE THE DANGER OF AGGRESSION!"

Reprinted from the Washington Post

MORE TEST EXERCISES

Two more "mock atom bomb raids" at Niagara Falls and at Utica, New York, gave local civil defense organizations an opportunity to test the effectiveness of their preparations.

These operations differed from most previous exercises of this type in that they were not entirely on paper.

The supposed "damage" included the loss of local fire-fighting equipment and breakage of water mains. Radio messages brought in equipment from neighboring communities, and long hose lines were required to fight the "fires" set off by the "bomb." In Utica car bodies previously left in the streets were cleared away by bulldozers to give a clear path for the fire engines. Medical teams practiced setting up first aid stations and swift transfer of patients from places of injury to emergency aid sites.

While the tests gave civil defense organizations some badly needed practice, the results showed that in a real disaster the operations would have been far less effective than necessary. Colonel Laurence Wilkinson, New York State Civil Defense Director, remarked that "The state of preparedness in New York State is so far short of minimum requirements to deal with an atomic attack that I am extremely apprehensive of what could happen if we should be attacked at this stage of the game." (But New York is conceded by most observers to be ahead of the majority of other states in civil defense legislation and preparation.)

CIVIL DEFENSE PUBLICATIONS

Worth-while publications have begun to appear in the civil defense field. *The Civil Defense Alert,* published by the Federal Civil Defense Administration, is a monthly which supplements the series of pamphlets and the news releases already coming in increasing numbers from FCDA.

Civil Defense News, appearing every two weeks, is an unofficial but reliable newsletter published from 1811 East Foothill Blvd., Altadena, California. Editors are Robert Pettengill and Albert Gotlieb, who were sponsors of the educational group, The Council on Atomic Implications, which recently terminated its activities. The

News is a four-page leaflet, typescript on letter-size pages.

Northeast Civil Defense, likewise appearing every two weeks, is done in newspaper style, and more devoted to local news of specific civil defense activities in Boston and New England. Published from 334 Boylston Street, Boston, it has a group of New England newspapermen on the editorial board, including James Sparkman of the *Christian Science Monitor,* which has also devoted a great deal of space to civil defense activities in the past year.

The first comprehensive sourcebook on civil defense to appear from a trade publisher is McGraw-Hill's *Civil Defense in Modern War,* priced at $6.00. Written by Augustin M. Prentiss, it outlines available information on bacterial, chemical, and incendiary agents, as well as atomic and high explosive attack, and discusses civil defense in all its phases, organizational and technical. Mr. Prentiss will be remembered for his previous books on civil defense in World War II. This book is well-illustrated and has an abundance of charts and figures useful to civil defense workers.

CIVIL DEFENSE RESEARCH GROUP

Consideration of fundamental civil and industrial defense problems has been since 1948 the prime function of a New York group recently incorporated as the Civil Defense Research Associates, Room 501, 475 Fifth Avenue, New York 17. Besides research, the organization intends to continue as a clearinghouse and maintain reference files on civil defense data. This new organization is an outgrowth of the "Civilian Protection Group," an unofficial seminar of persons interested in civil defense, which has met regularly to sponsor symposia of experts from various branches in the field. S. A. Anthony, Jr., continues to head the group, and it will continue publication of bibliographies, monographs, etc., and provide information from the largest private library on civil defense this side of the Atlantic.

ITEMS

Medical and surgical-supply companies are operating at capacity to meet civil and military demands. . . . New York has set up the first comprehensive "Rescue School." . . . Philadelphia is trying to recruit 4,000 auxiliary firemen, but city law prohibits volunteer firemen from riding on fire trucks. . . . Air Force Chief, General Hoyt Vandenberg, believes active defense might stop three out of ten enemy bombers; that would be three times better than Germany's defense against us. . . . A list of 25 British 16 mm. civil defense films is available from the British Information Services, 30 Rockefeller Plaza, New York 20; they may be purchased, or rented at nominal charges ($1.50 to $3.75). . . . Federal civil defense chief, Millard Caldwell, warns, "Our civilian populations have not been tested under fire for 135 years. We cannot be sure how they will respond to attack."

The Lebanon Township Civil Defense Council in New Jersey is distributing to every citizen a sample dental X-ray film packet. This is hung up by means of a paper clip and string. The theory is that the clip will show up on the film after developing, in the event that any rays strike it. How often the film packets will be changed is not announced.

NEW SAFETY-DESIGN FUME HOOD for handling Radioactive Isotopes

Design approved for use by Oak Ridge Institute of Nuclear Studies

- Air foils at hood face allow air to enter without turbulences.
- Low Velocity . . . operates with less than half the CFM of air needed on a conventional type hood.
- Air current directed across working surfaces removes heavy gases.
- Entire interior of hood is stainless steel for easy decontamination.
- Steel grating supports working surface, giving load carrying capacity up to 400 lbs. per sq. ft.
- Equipped with blower switch, warning light, and "over load" warning bell.
- All service controls outside—no reaching in.
- Outside measurements: Height 9 ft.; width 6 ft.; depth 3 ft. 6 in. Five inch Stainless Steel Sink welded into top.

Precision built by Kewaunee Mfg. Co., one of America's oldest and largest makers of fine Laboratory Equipment, including all types of Stainless Steel Equipment for Radioactive Laboratories.

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MANPOWER

LEONARD I. KATZIN

AS THIS is being written, the first tests of college students conducted by Selective Service, for the purpose of determining suitability for educational deferment, have been given. In the depths of arguments over administration of the tests and whether or not draft boards should consider their results, whether educational deferments are democratic or proper, etc., sight has been lost of the facts of life which have brought the whole problem into existence.

In 1910, before the First World War, the United States census showed a population of 92 millions. In the next decades it rose to 106 millions and 123 millions, and in 1940, before our entry into the Second World War, it stood at 132 millions. In 1950 the number was 151 millions. This population increase alone would have caused an increased demand for educated and trained people, to apply their education and training to the public welfare in all areas of the nation's life.

In the same forty years the airplane developed from an experimental curiosity to a machine which daily carries thousands of people across continents, oceans, and mountain ranges, bringing the other side of the world to the American fireside. The electronics industry has grown from nothing to the point at which almost every individual in the country is in daily contact with it in one form or another, and through radio, and now television, every American can hear what the people on the other side of the world say and what his own leaders say and do. Science and scientific technology have grown tremendously during the same period, with the discovery, development, and mass production of new aids to medicine; with the invasion of the atomic nucleus by man, the development of artificial radioactivity, atomic energy, and the many less-publicized achievements in increasing food production and in other ways. But the airplane can also carry bombs and guns and soldiers, the radio and electronics give fire-control radar, the proximity fuse, and beamed propaganda broadcasts, the developments in biology and chemistry may give biological warfare and poison gases, atomic energy has given the atomic bomb.

In brief, life in the last forty years has become more complex and involved: the fate of the individual is involved with that of the group even more than before, and the fate of America is more closely and immediately concerned with what happens from day to day at other places in the world than ever before. The need for information, wisdom, and education at all levels in the population is greater than in all history. Citizens are needed who can deal with the mechanical and social complexity and interplay of forces in general as well as in important detail, so that our civilization may reap the benefits of its advance rather than disaster.

We face the problem of how to maintain an armed force of three and one-half millions or more, for an indefinite period, without irretrievable damage to our political institutions and ways of life which this force is being mobilized to protect.

The contradictions inherent in the opposing pressures come into focus on the population group between 18 and 26 years of age. This is the group which the military deems most desirable for the armed forces. It also is the group which is just emerging from the spectator role of childhood in our civilization into the direct stream of participation in the life of the community by choosing and serving its apprenticeship in adult work. For some the taking up of duties in the community will be immediate; for others it is delayed further as they enter upon lengthy schooling for the more complicated and specialized vocations. It is from this age group that one expects the new ideas and major adaptations to the problems of the present and future—and the most easily trained and toughest soldiers.

Of the total labor force of the country, something over 61 million people, the scientific manpower pool (scientists and engineers) constitutes about 575,000—less than one per cent. Of this number, perhaps one-tenth are employed in basic research or teaching in colleges or universities; one-quarter work for government agencies, in administration or research and development; and the remaining two-thirds are in industry—production work, research and development, hospitals, consulting work, or commercial laboratories.

Some 10,500 of this group die or retire each year, and merely to maintain the numbers, would have to be replaced. In 1950, however, the record classes of 75,000 bachelor's degrees in the physical sciences and 52,000 graduates in engineering were snapped up by industry without satisfying the demand. In 1951 the prospects are for 46,800 science graduates and 38,000 engineers; in 1952, 35,800 science graduates and 26,000 engineers, and by 1954 the expected figures are 28,000 science graduates and 17,000 engineers. The figures quoted include, of course, the estimated 30 per cent or more who are in the ROTC, the NOTC, the ROC, the National Guard, and reservists, practically all of whom will be required to serve at least two years in military service. Of the 38,000 engineering graduates in 1951, industry is expected to get only 26,000. In 1956, when not more than 16,000 engineers are expected to obtain diplomas, industry expects to need a minimum of 30,000. It should also be pointed out that the projected figures for future numbers of graduates do not allow for draft calls nor any other interference with the present numbers of enrolled students, or prospective enrollees.

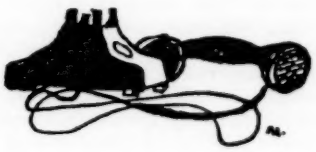
Industrial work in general is constantly calling for more men; the armed forces themselves want technically trained people for the constantly more complicated and involved mechanical and electronic equipment of the modern military machine. Civilian defense agencies, gradually coming into being, need technical men for the problems they face. Government agencies, such as those dealing with

public health, testing, development, and atomic energy, will need more technical people as a result of the military program. It has been stated by the Bureau of Labor Statistics that 93,000 students of each year's college entering class would have to be deferred to provide the needs in the healing arts, in science and engineering alone, not including any other fields.

Of the present total pool of 575,000 scientific and technical personnel, 65,000 are draft age (19 to 25 years old) and an estimated 100,000 are in armed forces reserves. It is almost six years since the end of World War II, so the two groups probably overlap very little, and the sum of those in the two categories may total 150,000 to 165,000. Removal of even a significant fraction of this total from the technical manpower pool would deal a crippling blow to the science and technology of the nation.

Of the 575,000 scientific and technical people in our population of 151,000,000, the men with Ph.d. degrees, upon whom the direction of the research and development programs depends, and from whom are to be expected the badly needed new discoveries and advances in fundamental scientific knowledge, number only 34,000. Of this number, some 35 per cent are in chemistry and 10 per cent in physics, with the remainder (including some 1,200 in engineering) distributed among the rest of the scientific disciplines—geology and geophysics, biological, agricultural, and medical sciences, astronomy, mathematics, meteorology, and so forth. The record pre-war number of Ph.d. degrees in the natural sciences was 2,034 degrees granted in 1941. In 1945 the number of Ph.d. degrees in the sciences had dropped to the low of 833. In 1946 it was 948, and only by 1949 was the pre-war peak surpassed. The zenith was the estimated 4,160 Ph.d. degrees in the natural sciences granted in 1950; from here the curve drops steeply. The decline in output of graduates with bachelor's degrees will shrink even more the pool from which Ph.d. candidates are drawn. Even the present stock of 34,000 Ph.d.'s is not all to be counted on, for some are still draft-eligible, and many are reserve officers in various branches of the armed forces, subject to call to active duty in capacities which will not use their technical or scientific backgrounds.

The 127,000 technical graduating class of 1950 is to a large extent the result of veterans having taken advantage of post-war educational benefits; this source of students is now essentially exhausted. It may also serve as an indicator of the time scale of lags introduced by interruption of the educational chain, since in large part these students would normally have been members of the classes of 1942–46, or thereabouts. There is no good criterion of what number of students might have taken degrees if their education had not been interrupted. The draft age of 18–19 may be taken as a mean age for high-school graduation. It takes four to five years to complete



an engineering curriculum, and seven to eight years after high-school, as a minimum, to do the work for a research degree, or a medical degree. The perspective and incentive for embarking on such courses of study are different at age 22 or 23, after a three- or four-year interruption of the academic habit, the development of financial independence, and perhaps acquisition of family responsibilities. It need hardly be stressed that not all have the desire and the aptitude to undergo these prolonged courses of study, nor to make use of them at their end. Without being able to put precise figures to the matter, the net balance of such interruptions is a loss in technical manpower.

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At the time this article was first written, the concluding paragraph read:

"These are some of the facts of the manpower situation as they apply to scientific and technical personnel. Similar considerations hold for teachers, economists, political scientists, historians, accountants, and other groups in our social complex. One looks forward to Selective Service and the local draft boards using statesmanship and the long-term view in handling the day-to-day problems of meeting draft quotas."

Since then the Congress has passed, and the President has signed into law, the new Selective Service Act, two important sections of which read as follows:

"Section 6 (*h*) The President is authorized, under such rules and regulations as he may prescribe, to provide for the deferment from training and service in the Armed Forces or from training in the National Security Training Corps of any or all categories of persons whose employment in industry, agriculture, or other occupation or employment . . . or whose activity in study, research, or medical, dental, veterinary, optometric, osteopathic, scientific, pharmaceutical, chiropractic, chiropodial, or other endeavors is found to be necessary to the maintenance of the national health, safety, or interest: *Provided,* That no person within any such category shall be deferred except upon the basis of his individual status: *Provided further,* That persons who are or may be deferred under the provisions of this section shall remain liable for training and service in the Armed Forces or for training in the National Security Training Corps . . . until the thirty-fifth anniversary of the date of their birth. . . .

"Notwithstanding any provisions of this Act, no local board, appeal board, or other agency of appeal shall be required to postpone or defer any person by reason of his activity in study, research, or medical, dental, veterinary, optometric, osteopathic, scientific, pharmaceutical, chiropractic, chiropodial, or other endeavors found to be necessary to the maintenance of the national health, safety, or interest solely on the basis of any test, examination, selection system, class standing, or any other means conducted, sponsored, administered, or prepared by any agency or department of the Federal Government or any private institution, corporation, association, partnership, or individual employed by an agency or department of the Federal Government."

"Section 6 (*i*) (2) Any person who while satisfactorily pursuing a full-time course of instruction at a college, university, or similar institution is ordered to report for induction . . . shall . . . be deferred (A) until the end of such academic year, or (B) until he ceases satisfactorily to pursue such course of instruction, whichever is the earlier: *Provided,* That any person who has heretofore had his induction postponed under the provisions of Section 6 (*i*) (2) of the Selective Service

Act of 1948; or any person who has heretofore been deferred as a student under Section 6 (*h*) of such act; or any person who hereafter is deferred under the provision of this subsection shall not be further deferred by reason of pursuit of a course of instruction at a college, university, or similar institution of learning except as may be provided by regulations prescribed by the President pursuant to the provisions of subsection (*h*) of this section. Nothing in this paragraph shall be deemed to preclude the President from providing by regulations prescribed under subsection (*h*) of this section, for the deferment from training and service in the Armed Forces or training in the National Security Training Corps of any category or categories of students for such periods of time as he may deem appropriate."

An admittedly extreme interpretation of the Selective Service Act is that college students may be deferred only for the completion of a single academic year; that draft boards are to ignore the results of the tests given by Selective Service, whose purpose was to try and determine the students whose drafting would be likely to cause the greatest loss to the brain power pool of the country, and that *no future selection system* in which the federal government has a hand is to be given any consideration. Nevertheless, the President is given the responsibility of providing for the deferment of essential persons "upon the basis of his *individual status*," while at the same time being told that he may provide "for the deferment . . . of any *category or categories* of students for such periods of time as he may deem appropriate."

The one thing that seems clear in the confusion of these apparently inconsistent admonitions and duties is that the problem of developing a mechanism for protecting the future of the country is left to the conscience of the individual draft boards, unless the ingenuity of the executive branch of the government can surmount the wording of the Act. One may perhaps consider the easiest expedient for reconciliation of the conflicts to be a resurrection of the wartime Army Student Training Program. This would face the conflict that the students would have to come within the statutorily limited strength of the armed forces.

Statesmanship and the long-term view will be needed even more by the Selective Service Boards.

QUOTES WITHOUT COMMENT . . .

Senator Brien McMahon (*Newsweek*, June 4, 1951):

"Our knowledge about atomic weapons—as compared with our knowledge in 1945—is almost the difference between a candle and a searchlight. Today we control a formidable stockpile that reflects accelerating progress in both numbers and quality. We now possess, for example, weapons far more powerful than the nominal one used at Nagasaki. The world of atomic energy in the military field is moving faster than we think. We have a variety of atomic weapons under development and in process of becoming available for military use in case of war. These include tactical weapons such as—to cite just one item—the so-called atomic artillery shell. In the future, it is likely that guided missiles with atomic warheads will figure prominently in our tactical arsenal.

"Radiological warfare is another factor in the over-all picture. However, the facts as at present known compel me to add that it would not be easy to produce large amounts of radioactive material for use in denying an enemy access to a given area."

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Millard Caldwell, Federal Civil Defense Administrator (in speech before the American National Red Cross Convention on June 25, 1951):

"Make no mistake about it. Russia is not going to be deterred by moral suasion of any kind—as we must in a Christian Democracy.

"Let's look for a moment at the Russian civil defense program and the general vulnerability of their sprawling land mass as it compares to America's.

"Is Russia or the United States most vulnerable to an all-out atomic attack?

"Early in World War II the Russians, knowing what was coming, began an intensive dispersal program of their industries and cities back behind the Ural mountains and into the vast Siberian wastes. That dispersal program was, and, from all reports, still is a massive effort.

"The Russian civil defense program has been in full-scale operation for a long time."

General J. Lawton Collins, Army Chief of Staff (in interview on television program "Armed Forces Hour" on June 4, 1950):

Question: I have heard that atomic bombs small enough to be carried by fighter planes have been developed. But can atomic weapons be developed for use by the army, too?

Collins: They most assuredly can be developed. We are working on systems, methods, and weapons by which, if it should be decided to use the atomic bomb, we could use it by army troops in support of army operations. We are doing a great deal of work in the field of developing weapons that the army can use with atomic fissionable materials. . . .

For example, it is by no means impossible to develop an artillery piece that would fire an atomic weapon. Similarly in the field of guided missiles. It is possible to develop guided missiles, which can be placed with accuracy in a given spot, which could carry an atomic warhead. Now, this point of accuracy is of great importance because we all know that there are bound to be certain errors in the dropping of bombs from high altitude. On the other hand, since the army is in immediate contact with an enemy, we feel that if we can develop weapons susceptible of firing atomic weapons, we can get specific accuracy with these weapons that will make tactical use of the atomic bomb practical.

Question: But if the enemy had these same weapons, wouldn't it make another Normandy almost impossible for us?

Collins: *Well, first of all, we don't believe the enemy would have these weapons because there is a limit to his industrial capacity and his research and development field.* We think that we can and are keeping ahead of him. Furthermore, these are essentially defensive weapons. We are certainly not going to initiate a war; and so therefore the things that we are doing are of greater value to the persons on the defense than it would be for the man who is on the offense. [Italics supplied by Editor.]

THE ENIWETOK TESTS

NEWS AND NOTES

Prepared by PETER AXEL

An official summary of the recent atomic bomb tests at Eniwetok was presented at a June 13 press conference sponsored jointly by the AEC and the Defense Department. The released information described a comprehensive testing program aimed at answering straightforward engineering and biomedical questions.

This sober picture of a broad experimental program gave no support to the newspaper and magazine accounts which were filled with sensational conjectures. The press has attempted to abstract from the exhaustive tests a single fact—a new "secret"—such as final success in the development of the hydrogen bomb. This sensationalism is somewhat analogous to the journalistic practice which has so successfully exploited the "secret" of the A-bomb.

The Eniwetok tests were begun in April and completed by the latter part of May. The AEC did not disclose how many bombs were used; Ralph E. Lapp, writing in the June 12 *Reporter,* gave the number as three. Each of the bombs was exploded while mounted on a tower so that necessary measurements could be made more easily. The sizes of the bombs, their destructive power, and the heights of the explosions were not given. However, it was stated that the test program "included detonations of sufficient energy yield to permit checking of the estimates and predictions as to the effect of . . ." weapons which are "several times more powerful than the Hiroshima-Nagasaki weapon."

Presumably it was either these experiments or those pertaining to thermonuclear reactions which were behind the reported comment of Dr. Edward Teller, of Los Alamos, that the atom bomb is obsolete. This comment was quoted by Representative Hebert of Louisiana in an AEC-cleared article published in *The New Orleans States* on June 16.

The thermonuclear aspects of the test appeared relatively minor when viewed from the perspective of the press conference, rather than from press reports. "The official statements have been carefully considered and there is no basis for interpretations which go beyond the actual words of the Commission's releases" cautioned Dr. Alvin C. Graves, chief of the weapons test division at Los Alamos. "I may say that we have gained new information and understanding of the basic phenomena underlying thermonuclear reactions. Most of the experimental projects designed to give specific information in the field of thermonuclear research were so novel and complex that we would have been happy if only a few of them had worked. It is a remarkable tribute to the laboratories and other agencies that participated in this work that so much useful information was secured for these projects."

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Gordon Dean, chairman of the AEC, was somewhat more positive and stated that the new information was not disappointing and would contribute to the production of the H-bomb. However, no positive indication was given that the H-bomb can be made. Further, Mr. Dean would not say whether the AEC would inform the public when and if an H-bomb is produced.

The effects of lingering radiation following the explosion of a bomb were summarized by Brigadier General James Cooney, Radiation Safety Adviser of the testing program. His comments were not based on newly acquired data; they were directed at publicizing previously acquired information in order to assist in the development of an intelligent civilian defense program. General Cooney said "Our experience in recent test programs repeatedly has demonstrated that radiation hazards will not delay rescue and recovery work after an air burst of an atomic bomb. There is no reason why every casualty can not be removed and treated immediately without serious radiation hazard to rescuers. In the case of a high aerial burst of an atomic weapon," he said, "such as I think will probably be used, there would be no residual radiation. In a low air burst just above the ground's surface, the significant residual radiation would be confined to an area 300 to 400 yards in radius. No rescue work would be required in this area because it would be devastated. Rescuers outside of this area would not be subjected to injurious ionizing radiation in reaching survivors."

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The following description of the types of tests made at Eniwetok is an excerpt from the statement presented to the press conference by Lieutenant General Elwood R. Quesada, U.S. Air Force, who was in command during the Eniwetok tests.

"The objectives of the operation . . . were to test new and improved weapon designs, to conduct experiments contributing to research on thermonuclear weapons, to expand our knowledge of the fundamentals of atomic blasts, and to study the direct effects of atomic weapons.

"To meet these objectives, the following experimental programs were conducted: weapon performance and phenomonology; biomedical research; blast effects on structures; atomic cloud physics; radiac instrument evaluation; physical tests and measurements; and blast effects on aircraft.

"The weapon performance program measured the efficiency and yield of each detonation. Within the first few microseconds, (one millionth of a second) the nuclear reactions were examined in detail. The phenomena associated with atomic explosions—blast, heat, and ionizing radiation—were also studied in detail.

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"The objectives of this complex program, and I assure you that it was complex, were to prove new atomic bomb designs, to contribute to research on thermonuclear weapons and to develop a fuller basic knowledge of the effects of the very great energies released in a detonation. This basic knowledge is essential to a better un-

derstanding of specific effects such as were investigated by the other programs.

"The biomedical program studied the effects of nuclear detonations on skin tissues, glands, and circulatory systems. Mice, dogs, and pigs were used in these experiments. All were bred and raised at Eniwetok in order that they might be acclimated to the environment, thus making possible essential controlled studies, some of which are complete, others are continuing.

"The mouse is useful since there is a wealth of laboratory background material on mice. Swine were used because their skin resembles that of man. The dog was used because its circulatory system resembles that of man. The objective of the biomedical program was primarily to provide a background for the development of treatments of atomic bomb casualties.

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"Laboratory studies of the glands and tissues of exposed animals are continuing in the United States, and thousands of mice have been returned. The work at present is being carried on at Los Alamos, Oak Ridge, University of Rochester, Department of Agriculture, Armed Forces Institute of Pathology, Naval Medical Research Institute, University of California, and California Institute of Technology.

"The structures program included the testing of various designs and types of construction, using various engineering principles and materials. The reactions of underground and surface shelters, industrial plants, and dwellings were recorded. The objectives of this program were to establish a method of predicting blast damage and to gain information useful in developing designs to minimize blast damage to military and industrial facilities.

"Some nine hundred measurements were made on twenty-seven various structures. A variety of glass and window construction was tested for the Civil Defense Administration. Although most of the structures program was developed and conducted by the three armed services, the information gained will be of significant value to civil defense and will be made available to the Civil Defense Administration as soon as it is assembled and analyzed.

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"The cloud physics program investigated the growth and rise of the atomic cloud and plotted the associated radiation fields. The objective of this program was a better understanding of the radiation of the cloud and its meteorological structure.

"The radiac evaluation program field-tested various models of badges and dosimeters. The program also included experimentation in the field of new radiation detection devices. Various types of meters and recording devices were exposed. This program will contribute to the design of simple, reliable radiation detection instruments required by many agencies and activities.

"The physical tests and measurements program included the exposure of Sherman tanks, protective clothing, the study of contamination and de-contamination problems, the study of fall-out patterns, and particle size of fission fragments and the development of filter materials to screen radioactive particles. The broad objectives of this program were to test military equipment and to better understand the nature of the problems posed by atomic detonations.

"Drone T-33s, drone B-17s, manned B-50s, and a manned B-47 were exposed to varying degrees of blast and heat. These aircraft were all carefully instrumented to record stresses and pressures. Manned aircraft remained at safe distances, while drone aircraft were vectored close to zero.

"Information gained from these airplanes was supplemented by exposure on the ground of instrumented aircraft components, wings, model airfoils, and fuselages. The purpose of this program was to collect data useful in developing tactics of operations in the close vicinity of atomic blasts as well as to assist in establishing design criteria for new combat aircraft."

SCIENTIST "X" DISMISSED BY MINNESOTA

Dr. Joseph W. Weinberg, who had been referred to by the House Un-American Activities Committee as "Scientist X," was dismissed on June 16 from his assistant professorship in physics at the University of Minnesota. The Board of Regents granted him a year's pay.

The dismissal undoubtedly resulted from Dr. Weinberg's difficulties with federal authorities, but no explicit reason was given in the AP dispatch. Dr. Weinberg had been questioned by the Un-American Activities Committee in May 1949. The committee's accusations that Dr. Weinberg—"scientist X"—was involved in giving atomic secrets to Communists have never led to any court action. Dr. Weinberg has also been called before a federal grand jury in Washington several times, but has never been indicted.

On May 11, 1951, this grand jury cited Dr. Weinberg for contempt for refusing to answer questions about his activities in 1943. He was cleared of the contempt charge on May 17 by U.S. District Judge Holtzoff. The judge upheld Dr. Weinberg's right not to give any testimony which he might consider incriminating.

On May 16, the president of the University of Minnesota, Dr. J. L. Morrill, suspended Dr. Weinberg for refusing to cooperate with federal authorities. Dr. Morrill indicated that the outcome of the then pending contempt citation would not influence the suspension. Presumably, refusal to cooperate with federal officials—even though it was later found legal by the court—was considered by the president as warranting Dr. Weinberg's dismissal.

CALIFORNIA LOYALTY OATH

The non-signers of the "loyalty oath" prepared for another long period of litigation when the California State Supreme Court announced its decision on May 31 to review the case of Tolman vs. Underhill (University of California oath controversy).[1]

On April 6, the Court of Appeals had declared that the oath requirement violated the California State Constitution. The Regents had until May 17 to petition for a hearing by the State Supreme Court; this petition was filed by the counsel for the Regents just before the deadline.

However, on May 25, the Regents voted to withdraw the appeal by a vote of 11 to 10. This confirmed the action they had taken at their meeting of April 20; at this earlier meeting Regent Neylon had given notice that he would move for reconsideration.

The State Supreme Court decided to review the case on its own motion. At the same time, the Court took over from various lower courts a number of cases involving other loyalty oaths, including the oath required under the recently passed Levering Act, from all state employees.

The two immediate consequences of the Court's action are that the Appeals Court decision favoring the faculty has been suspended and that the non-signees have not been reinstated.

[1] See article by G. Chew, *Bulletin*, VI (November 1950), 333, and news item, *Bulletin*, VII (May 1951), 156.

A LAST WORD

DEAR READER:

The *Bulletin of the Atomic Scientists* is planning new techniques and new features for itself—its circulation is increasing, and the field of news and controversy it covers is constantly expanding.

We invite your constructive criticism, either on specific articles or on the general tone and content of the *Bulletin*.

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This fall we plan a special issue devoted entirely to aspects of SCIENTISTS AND LOYALTY. It will cover, among other things, the nature and operation of the new quasi-judicial procedures now being developed to "prove" loyalty . . . the philosophical basis for the loyalty-concept . . . what *is* loyalty? . . . and examine why in the past we have failed to detect the real traitors such as Klaus Fuchs.

In this issue, the *Bulletin* will print verbatim excerpts from an Atomic Energy Commission loyalty hearing. To our knowledge this will be the first reporting any magazine has given of what actually happens in these private "courtrooms."

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In the second special issue of the *Bulletin* to be devoted to civil defense, the DISPERSAL issue will examine a topic which seldom makes headlines.

The subject is "defense-through-decentralization," and we believe this is the first symposium any magazine has assembled upon the subject of dispersing industry or populations against atomic attack.

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The *Bulletin* also has under consideration for later this fall a special symposium upon "Peaceful Alternatives" to the armaments race and the cold war.

We invite *your* suggestions as to how we can best meet the challenge of reporting today's news and tomorrow's history.

—THE BULLETIN STAFF

"AND OUR BONES ACHE"

Despina is a six-year-old war orphan. Her father contracted tuberculosis in the Greek Army. He was released and sent back to his village and family. There, the disease was communicated to the mother, while she was nursing her husband. They both died this past winter. The child writes this in a letter to her American Foster Parents.

"You are my only hope in life, as I am a complete orphan. I live with my Granny, who is very old, and my little sister. When our mother and father died last winter, Granny burned the mattresses and the covers they had on their beds. And now we sleep on the very hard boards . . . and our bones ache."

This child is but one of thousands needing help. Many have been maimed and disfigured by war. Funds are needed for plastic surgery, artificial eyes and prosthetic limbs.

You, alone, or a group can help the thousands of war children now in desperate need overseas, by becoming a Foster Parent. You will receive a case history and photograph of your child. Correspondence through our office is encouraged.

The Plan is helping children of fourteen different nationalities in Greece, France, Belgium, Italy, Holland, and England. By aiding these children you are working for the greatest aim of all . . . for peace. The Foster Parents' Plan does not do mass relief. Each child is treated as an individual with the idea that besides food, clothing, shelter and education, the child will live in the homelike atmosphere and receive loving care that so rightfully belongs to childhood.

Partial List of Sponsors and Foster Parents

Nancy Craig · Mary Pickford · Mrs. William Paley · Mr. and Mrs. Fredric March · Joan Bennett · Helen Hayes · Edward R. Murrow · Larry LeSueur · Ned Calmer

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